ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. 57. No. 8. 220 Broadway, New York, February 21, 1907.

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CONSTRUCTION OF THE ALASKA CENTRAL RAILWAY, WITH COST DATA.

By WM. G. ATWOOD.*

The Alaska Central Railway is projected to connect an ice-free harbor on the Pacific coast with the navigable waters of the Yukon River system. Its general location is shown in the map, Fig. 1. When completed this road will have a main line 467 miles in length, with a branch of 40 miles leaving the main line at Mile 149 and extending to the eastward into the coal fields of the Matanuska River.

A satisfactory harbor was selected in Resurrection Bay, and a town called Seward was established at that point. The establishment of this town and the early construction work on the road were described in Engineering News, Sept. 8, 1904, but the ownership of the road changed hands about that time, and the character of the work and the methods used were materially altered. Only the work done since, January, 1905, will be considered in this paper.

Under the former owners the location surveys were carried only a short distance beyond the construction, but on the acquisition of the property by the new owners the force engaged on surveys was much augmented. A preliminary line was run over alternate routes from Mile 34 to Turnagain Arm of Cook Inlet. This work was done in the winter, when there was snow from 10 to 20 ft. deep on the mountain passes which were crossed. The parties consisted of about 14 men, exclusive of freighters driving dog teams, whose numbers depended on the distance of the parties from their base of supplies. All supplies had to be moved by dog teams, since the depth of snow precluded the use of horses, but owing to the scarcity of dogs it was often necessary for the survey work to be stopped and the supplies moved by the parties themselves on hand sleds.

The line selected crossed the watershed, between Kenai Lake and Turnagain Arm at an elevation of 1,050 ft. above sea level at the head of Placer River, a distance of 45 miles from Seward. The valley of Placer River furnished some very interesting location work and a great amount of heavy construction. This valley is of comparatively recent glacial formation, two of the glaciers which formed it being still in existence, though they have entirely receded from the main valley.

The established maximum grade of 2.2%, compensated for curvature, was easily obtained from the summit at Mile 45 to Mile 48 by following the water grade of Placer River. At this point there is an almost vertical descent in the general level of the valley of about 200 ft., marking the place where the now extinct glacier, coming from the mountains on either side of the pass, met the still existing (Bartlett) glacier. This combined glacier formerly extended about 1½ miles further north to the head of a box canyon 500 to 800 ft. in depth, which has been probably eroded by the melting waters of the glaciers. This canyon, 4,500 ft. in length, ends at the foot of the second (Placer River) glacier, which formerly extended to Turnagain Arm. The valley from this point to the head of Turnagain Arm is flat and swampy, with an elevation of 150 ft. at Mile 54, descending to sea level at Mile 67.

BRIDGE FOR PIPE LINE AND TRAIL.

A locating party under Mr. Frank Bartlett, locating engineer, began work on this division in March, 1905, and completed the location in November of that year. The development had to be obtained between Miles 48 and 54, so this area was very carefully studied for a 3.1% grade as well as for a 2.2% grade. Seven preliminary and location lines were run and a 2.2% grade finally obtained, although it was necessary to exceed the 12° limit of curvature twice by inserting two 14° curves; one of these had a central angle of 238° and the other of 213°. This territory was covered with a very dense growth of alders. Many of the slopes were very steep, and in the canyon the men had to work on ropes or points had to be located by triangulation. An approximate plan of the development between Mile 47 and Mile 53 is shown in Fig. 2.

Tunnel No. 1, 699 ft. long, is entered close to the P. C. of the first 14°-curve (on Mile 49), and from the tunnel the line passes out on a trestle about 1,600 ft. in length and from 40 to 90 ft. high on the center line. A portion of this trestle is on a side hill and has one leg 160 ft. long for a few bents. Near Mile Post 52 the line reaches the head of the canyon and crosses it on a Howe truss deck span of 120 ft. The road is located for the full length of the canyon from 150 to 200 ft. above the river. In this portion of the line there are six tunnels and several very heavy rock cuts, one of them being 150 ft. deep on the inside slope and from nothing to 30 ft. on the outside, with a total yardage of 28,000 cu. yds. in 300 ft. Fig. 3 is a view of this cut from the north portal of Tunnel No. 6; the men are standing at the level of the grade line, and the ladders (150 ft. high) reach to the trail above.

After passing out of the canyon the line follows the side hill for about a mile; then the terminal moraine of the Placer River glacier and the center of the low valley to Turnagain Arm. The north shore of Turnagain Arm is followed from Mile 67 to Mile 101, and aside from crossing the valleys of some small streams the line is on a steep side hill. Three locating parties were placed on this work as soon as navigation was open in Cook Inlet, in April, and they were not able to complete the work until November. The supplies for these parties were delivered to them by water, and in addition to the regular members of the party there were one or two boatmen, experienced on these waters. Turnagain Arm is a very dangerous body of water, since it has a tidal rise and fall estimated at 50 ft. and currents as high as 10 knots per hour, with several bad tide rips. The general elevation of grade is about 50 ft. above high tide, though in places it reaches 100 ft. The work of the sur-

*Late Assistant Engineer of Construction, Alaska Central Ry.

vey parties was very dangerous, much of it having to be done on ropes, and some of it triangulated.

From Mile 101 to Knik Junction, at Mile 149, the location along the shores of Knik Arm was made by one party in the winter of 1905-1906, while another party located the 40-mile branch

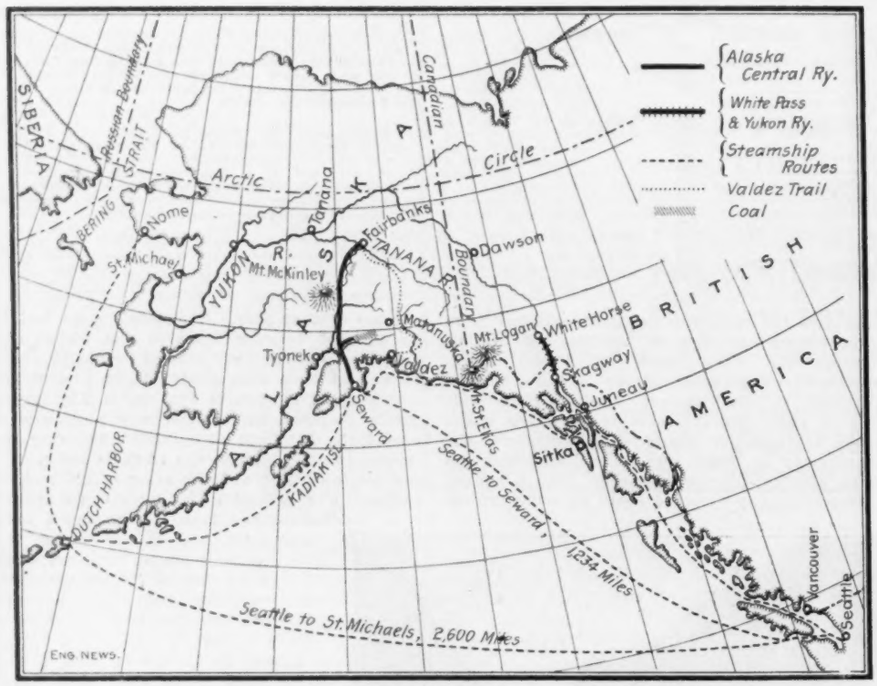

FIG. 1. MAP OF THE ALASKA CENTRAL RY. (467 MILES.)

up the valley of the Matanuska River to the coal fields.

During the summer of 1905 a preliminary line was run from Knik Junction to Mile 206, on the Sushitna River, and the following winter two parties made a stadia survey from that point to the northern terminus of the road, at Fairbanks, on the Tanana River, Mile 467. These parties began work in January, one at Mile 206, the other at Fairbanks, and connected their lines in May near Broad Pass, in the Alaskan Range. They carried with them supplies enough to complete their work and return to the coast. They were furnished with four dog teams of four dogs each as their sole means of transportation. Such a team of good native dogs can haul about 400 lbs. on a fair trail about 25 miles per day. The average cost of the survey parties was about $2,000 per month for salary, subsistence and transportation.

New construction work was started on Mile 18 in April, 1905. The work was supervised by the resident engineers, to whom the foremen in charge of camps reported. Residencies Nos. 2, 3 and 4 were all in the valleys of Kenai Lake and its tributary Trail Creek, which has its source on Mile 45.

The pile trestles on residency No. 3 were built with four-pile bents, 12-ft. span, and an average length of piles of 22 ft. The floor system consisted of six 8 × 14-in. stringers per span, with 7 × 8-in. ties, 10 ft. long, spaced 14 ins. c. to c., and guard rails 5½ × 8 ins. The 12 × 14-in. caps were hewed, and they, as well as the piles, were cut as close to the bridge sites as possible and floated to place. The sawed timber was furnished by the company's mill at Seward. There were 3,514 lin. ft. of trestle built on residency No. 3, at a cost of $6.40 per lin. ft., including the cost of moving the pile-driver between bridges.

On Mile 35 a rock fill containing 4,524 cu. yds. was made from borrow, with an average haul of 700 ft., made in Peteler cars of 1 cu. yd. capacity. A 3⅛-in. steam drill, supplied with steam by a 10-HP. vertical boiler, was used in the borrow pit, and the rock (a hard slate) was moved for $1.06 per yd. On Mile 36 a fill of 4,488 cu. yds. was made in a swamp with Peteler cars from an earth borrow-pit 3 ft. deep, after a haul averaging 3,522 ft. down a 1%-grade. Cars of 1 yd. capacity, in 10-car trains, hauled by two horses per train, were used. The cars were loaded by hand, and the fill cost 38.6 cts. per yd.

On Mile 38 a similar fill was made with the same equipment and methods, except that the pit was only 2 ft. deep, and the haul was 4,133 ft. down a grade of 0.6%. This fill contained 5,283 yds. and cost 46.1 cts. per yd. The material in both cases was a fine slate gravel. No steam shovels were used on the work, all excavation being done by hand labor.

Miles 44 and 45 were not completed until January, after there had been a heavy snowfall, which required a large amount of snow-shoveling. Then, too, in December in this latitude (60° North) the days are only about six hours long; and while the men worked eight hours for ten hours' pay, their work was very inefficient for a part of the time. These conditions increased the cost of the rock excavation (which amounted to 14,871 yds. on Mile 44 and 19,411 yds. on Mile 45) by about 75% over that of work done under more favorable conditions. The material on both Miles 44 and 45 was a hard syenite, and on Mile 44 required 1.3 lbs. of powder, while 2 lbs. were used on Mile 45, owing to the fact that the weather was so cold during a part of the time when work was in progress on Mile 45 that it was impossible to load the holes without a portion of the powder being frozen.

The grading on residency No. 5, which extended from Mile 45 to Mile 52, did not offer any serious problems until Tunnel No. 1 was reached on Mile 49. This tunnel is 699 ft. long, in a hard, blocky slate, which gave considerable overbreak in some parts. Fig. 4 is a view of the north portal of this tunnel, and shows the character of the rock. The plant used in driving this tunnel consisted of a 40-HP. boiler of locomotive type, an air compressor with a rated capacity of three drills, and a 10-HP. vertical boiler and boiler feed pump for delivering water to the compressor plant at the north portal of the tunnel. This tunnel was driven entirely from the north portal, to take advantage of the favorable grade for hauling spoil, and because there was a large snow-slide over the south portal, which made work at that point dangerous. For about 200 ft. this tunnel was driven by using steam in the drills instead of air. The drills were connected with the boiler in the usual way, and the exhaust carried from them in a 2-in. steam hose to a 12-in. square wooden box with a vent outside the tunnel. This method was a success until the heading had been driven about 300 ft., when the heat became excessive. Driving a tunnel with steam drills is practical and economical in a short tunnel, where the freight on machinery is very high, and it is impossible to obtain a sufficient number of competent hand drillers, although the amount of steam hose consumed is very large. In this tunnel it would have been more economical to have installed the compressor at the beginning, and so saved this large expenditure.

The standard tunnel section is 21 ft. high above sub-grade and 14 ft. wide in the clear on tangents; it is widened to 16 ft. on 12° and 14° curves, and the center line of the track so located with reference to the center of the tunnel as to give the maximum clearance. Tunnel No. 1 is so located that all supplies had to be hauled two miles from the end of the track by freight team and about ⅝-mile up a trail too steep and crooked for the four-horse teams. A single horse on a sled or "stone-boat" was used here.

The distribution of costs in this tunnel is set forth for the month of May, 1906, which month is a fair type of the whole work:

Yardage moved during month	2,109 cu. yds.
Labor, and tool depreciation	$5,346.26
Explosives	842.32
Lighting	165.20
Coal	285.00
Bonus	281.10
Total	$6,919.88

A bonus of 50 cts. per ft. was paid each man who worked a full week in this tunnel, regardless of his rate of pay, for every foot progress beyond 24 ft. This same system was followed in the other tunnels, with a different amount of progress required in each.

There is a great amount of timber trestle in this division, and owing to the fact that there was no suitable timber for the work available in the Placer River Valley, the span of 12 ft., which had been standard on other portions of the road, was changed to 20 ft., with the result that the stringers had to be increased in size and number. The stringers were increased from six 8 × 14 ins. per span to eight 9 × 18 ins. All posts were

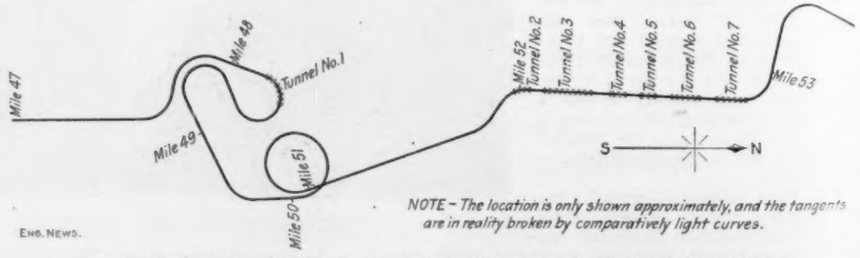

FIG. 2. LOCATION OF THE ALASKA CENTRAL RY. FROM MILE 47 TO MILE 53.

round timber, mud sills were hewed, and all other timber in the sub-structure was sawed in the company's mill at Seward. This bridge work was contracted to a firm in the State of Washington, who cut all the round and hewed timber, hauled it to the track, loaded it on cars, unloaded it at the end of the track, and hauled it to the bridge site. The company furnished all iron and sawed timber f. o. b. cars at the end of the track, and the contractors had to haul it

from that point. Fig. 5 shows a high trestle on Mile 18, with a 40-ft. span over a stream; a set of A-frames above this opening support the intercepted bent in the upper panels.

The power plant for driving the series of tunnels in the Placer River canyon had to be located about 400 ft. south of the south portal of

FIG. 3. A 150-FT. SIDEHILL CUT; NORTH OF TUNNEL NO. 6.

the No. 2 tunnel, and on the opposite side of the canyon, so that coal and other supplies could be delivered to the plant by the regular four-horse freight teams. This location forced the use of about 7,000 ft. of air pipe to reach the north portal of the No. 7 tunnel. This plant consisted of four 40-HP. boilers and two compressors with a rated capacity of about 600 ft. of free air per minute, which was slightly increased owing to the excess of boiler power.

It was necessary to build a temporary bridge across the canyon to carry the air pipe line and to serve as a foot-bridge for the men. This bridge was suspended on four ¾-in. steel cables, with a stiffening truss made of 2 × 4-in. and 2 × 6-in. timbers, bolted at the joints. This structure was so stiff that no leaks were developed in the pipe line, even though horses and dump-cars passed over the bridge. The labor and material for the structure cost about $1,300. The photogravure on page 199 is a view of this structure, and along the left wall of the canyon, near the top, may be distinguished the line of the trail.

A pack-trail for horses was built over the tunnels, in some places being blasted out of the canyon wall. This trail became impassable for horses during the winter, owing to the frequent snow-slides, and all materials and supplies had to be delivered to the tunnels by packing on men's backs, except that by a detour of about seven miles over the Placer River glacier, a portion of the road being on a 12% grade, it was possible to reach a point about 1,000 ft. from the north portal of the No. 7 tunnel with four-horse teams.

Tunnels Nos. 4 and 5 and a portion of No. 6 were driven by station men doing hand drilling. No. 2 was built by the company, being driven from the north end, as was No. 7, while No. 3 was driven from both portals. A contract for all six tunnels was let, but after a small amount of work had been done the construction was taken over by the company. The costs for Tunnels Nos. 2 and 3, given below, are for labor and material used by the company on the tunnels, and do not include the cost of the plant, the expenditures of the contractor or the engineering expense. Tunnel No. 2 is 300 ft. long, of which 75 ft. was driven by the contractor and the remainder by the company, with cost distribution as shown in the accompanying table.

About 3.1 lbs. of powder and 69 lbs. of coal per yd. were used in Tunnel No. 2. The rock was a hard, blocky slate, with a great number of quartz seams, and in places gave a rather poor roof.

Tunnel No. 3 is 955 ft. long, and is in a hard slate, with a definite plane of cleavage at right angles to the axis of the tunnel. This formation required the use of a considerable amount of powder, but broke almost exactly at the drill holes. Eight hundred and forty-four ft. of this tunnel was driven by the company, with a cost distribution as shown in the table. About 4.2 lbs. of powder and 58 lbs. of coal per yd. were used in this tunnel.

The cost of driving Tunnels No. 6 and No. 7 was about the same per yard as that of No. 2, and with about the same distribution, except that the expense of the compressor plant was slightly heavier, owing to the distance of the drills from the compressor. The tunnel timbering consisted of 12 × 12-in. sills, 12 × 12-in. posts 14 ft. long, a 12 × 12-in, plate, five segment timbers 12 × 12 ins., and lagging of 3-in. or 4-in. plank. Timber sets are 4 ft. c. to c. The timbering in Tunnel No. 1 cost about $21 per 1,000 ft. B. M.

COST OF TUNNEL WORK.

	Tunnel No. 2		Tunnel No. 3	
	Per cu. yd.	Per lin. ft.	Per cu. yd.	Per lin ft.
Labor, and tool depreciation	$3.17	$38.26	$3.57	$38.39
Light	.13	1.57	.14	1.57
Explosives	.62	7.48	.85	9.20
Compressor, labor, fuel, etc.	.65	7.85	.57	6.10
Total	$4.57	$55.16	$5.13	$55.26

Yardage moved: Tunnel No. 2—2,717 cu. yds. in 225.1 ft.; Tunnel No. 3—9,078 cu. yds. in 844 ft.

Fig. 4. North Portal of Tunnel No 1; Alaska Central Ry.

Wages paid labor on this work were as follows, being per day of 10 hours:

Foremen of tie, grading and logging camps	$5.00
Sub-foremen in all branches	$3.50 to 4.50
Machine drillers in tunnels, and blacksmiths	4.00
Teamsters, hand drillers, tool dressers, firemen in the compressor plants	3.00
All common labor	2.75

Horses were figured at $1.50 per day, including forage, shoeing, etc.

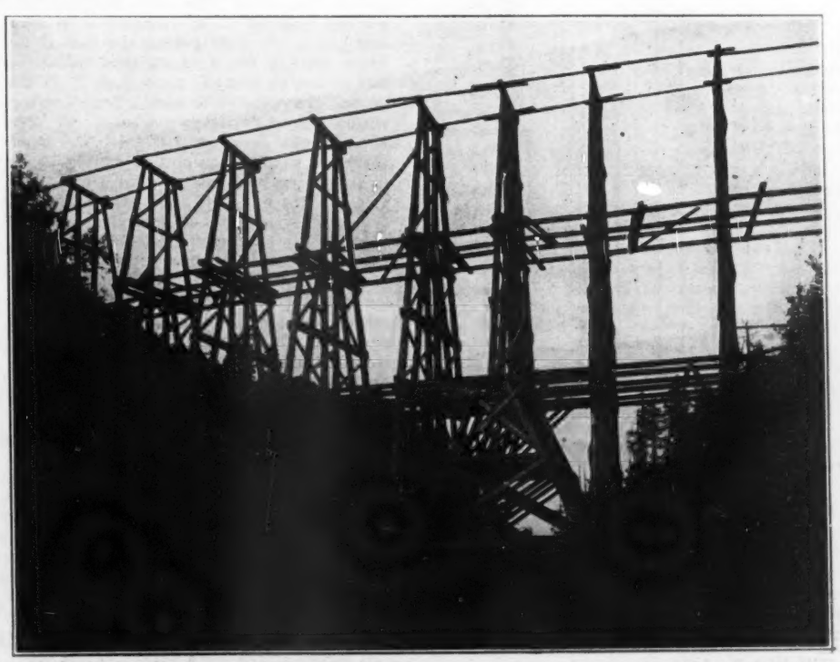

FIG. 5. HIGH TRESTLE WITH A-FRAME SUPPORTING A BENT OVER A 40-FT. OPENING.

One problem of considerable importance in the carrying on of work in a cold climate, that of thawing dynamite, was solved by a method which the writer believes to be new. The common method of thawing by open fires is dangerous, and the hot-water method by immersing a vessel containing the dynamite in hot water is too slow where a quantity of power is needed. Thawing dynamite in a house containing a stove is very dangerous, because the house so often becomes overheated. On this work several houses, with a greater or less amount of powder, had been lost by explosion and fire, when Mr. J. B. Cameron, Engineer of Construction, put a new system in use. Two small houses were built about 12 ft. to 18 ft. apart and connected by two air ducts, one at the floor level and the other in the gable. These ducts were made of 1-in. lumber and both ducts and houses were covered with so-called fireproof roofing. The stove was placed in one house and the dynamite on racks in the other. With this method there is no danger of the powder becoming overheated and no difficulty in keeping a sufficient supply of thawed powder on hand. After the system of double houses was put in use only one house was burned, although several times the house containing the stove became ignited and the fire was extinguished before serious damage was done.

SINKING A SHAFT WITH STEEL AND CONCRETE LINING IN SOFT GROUND.

By W. E. WAGNER.*

The waterproofing of concrete has ever proved one of the most vexing difficulties that an engineer has to encounter, especially if the nature of the work is such that the surface in contact with the water cannot be coated with a waterproof paint or a coal tar pitch and felt covering. If added to this it proves impossible to exclude the water while laying concrete, the problem becomes one to cause many an anxious moment during construction and often a never ceasing worry and vexation afterwards.

The following should prove interesting as an illustration of such a case in which the waterproofing under a heavy pressure, at first almost despaired of, proved successful in the end beyond the utmost anticipation.

The work in question was the sinking of a shaft for a shot tower by the Equitable Powder Mfg. Co., of East Alton, Ill. The shaft was required to be 6 ft. in diameter and 80 ft. deep,

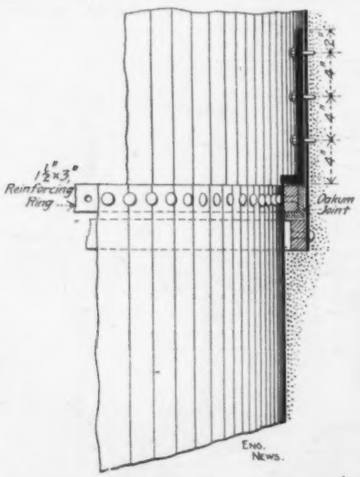

Fig. 1. Method of Connecting Adjoining Sections of Casing in Sinking a Well Through Water-Bearing Sand and Clay, at Alton, Ill.

necessitating a hole 7 ft. 6 ins. in diameter to allow for a 9-in. wall of concrete. A test hole showed that the ground consisted of successive strata of moist sand and clay overlaying a base under a very heavy pressure of water. The works are located about two miles from the Mississippi River and close to a sand deposit, which it is claimed at one time formed the course of the river, and this was verified by finding branches of trees in perfect condition, though spongy from age, at the depth of 80 ft. from the surface. This will account for the many and varied strata of clay and sand encountered in excavation.

Owing to the nature of the soil and the facilities at hand it was thought impossible to force down a casing of uniform diameter in one piece. It was decided, therefore, to build the casing in eight sections, each of uniform diameter, varying in size from 10 ft. 6 ins. for the top to 7 ft. 6 ins. for the bottom, each section being 5 ins. less diameter than the one above it. The sections were built of 5-16-in. steel with a reinforcing ring 1½ ins. by 3 ins., riveted, as shown in Fig. 1, to the top of the outside and the bottom of the inside of each casing. The joints between these rings were stuffed with oakum when the lower casing reached its final position. Angle pieces, also shown in Fig. 1, of 1½ × 3-in. iron were bolted to the casings, to connect the adjoining sections and prevent the upper one from slipping.

The well was started by excavating the earth so that the casing sank of its own accord. As the material became stiffer, eight jacks applied around the rim were used. By this method the hole was driven with no extraordinary difficulty until at a depth of about 30 ft. the water pressure began to give trouble. From this time on the joints between sections would occasionally break loose and pour large volumes of water together with sand and clay into the well. It was these joints that caused the writer most uneasiness as they could be caulked only with great difficulty. They could not be tightened up enough to pour with lead and by no other means could they be made dry enough to deposit concrete against them, for even the smallest leak would create a pressure that would wash through green cement. The plan was tried of bolting iron above the oakum to hold it in place, but it was found that when the oakum became old and softened it leaked very freely and fresh oakum had to be forced into the joint so that any obstruction was more of a hindrance than a help.

At about 60 ft. depth a new difficulty arose; the great pressure on the outside suddenly caused a boiling up of sand and water, piling up 3 ft. or 4 ft. of sand within the casing. By removing this sand carefully and forcing down the casing with all the power that could be exerted a foot or two could be gained before another rush of sand and water temporarily suspended the work. The leaks through the joints already referred to, by carrying with them clay and sand, left voids behind the casing, and the earth settling down to fill these spaces caused the ground to crack in a circle 40 ft. in diameter around the well. The casing tripod and ground within this circle slowly settled down. This was not thought very serious until the heavy inrushes of sand in the bottom caused the ground to sink 2 ins. or 3 ins. at a time, and these sudden changes of such a great mass of earth shifted the sections of casing, tearing off the angle braces by shearing off the bolts.

It was decided at this point to abandon any ideas of sinking lower, for though the last casing had not been put down, an extra 7 ft. was gained by the cracking and settling of the ground to that extent. However before preparations could be made for concreting, a heavy flow broke through between casings 4 and 5 and the subsequent movement of earth squeezed the shell into an egg shape. Fearing that the whole casing would collapse if the flow of clay continued, the well was allowed to fill up to relieve the pressure. Subsequent soundings showed that the hole filled up 20 ft. with clay and sand before the flow stopped. As winter was now on and the work in the water could only be carried on at great disadvantage it was thought best to let it stand till spring and allow the ground to settle and become firm.

During all the previous operations the well had been emptied by a pump hanging from adjustable cables at the clear bottom of the shaft. In addition to being constantly in the way of the workmen this pump would be submerged when for any reason the steam plant had to shut down. When the work was resumed in the spring the pumping was carried on by means of a deep well pump, steam driven, which was set up on cross timbers over the top of the well. This was provided with a brass slotted tube strainer connected to the drop pipe by a slip joint, thus allowing the strainer to remain on the

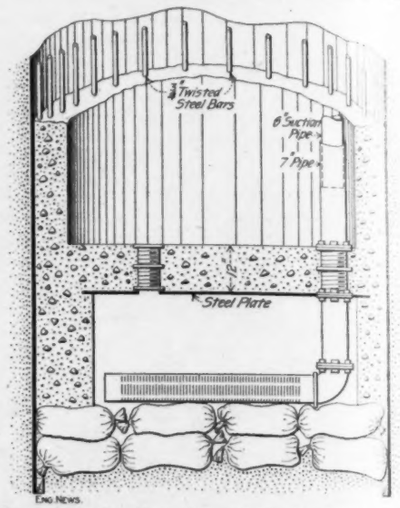

Fig. 2. Section Through Bottom of a Waterproof Shaft, Showing Method of Holding Sand Bottom from Blowing in, by Use of Concrete in Bags.

bottom of the hole and lower by its own weight with the excavation.

Although a great advantage was gained in having the additional room and in having all the steam pipes and working parts above ground in reach of the engineer, by far the greatest advantage was found to be the manner in which the water was kept down at all times. With the duplex pump the suction had to be kept submerged requiring the men to dig for most of the time with hands under the water, whereas with the deep well pump it was found to be an advantage to keep it running fast enough to hold the water below the top of the strainer. By doing this a certain amount of water would slush back after each stroke and clean the strainer, which on account of lying on the bottom would clog up if completely submerged. It was thus found that the pump was self-governed and would hold the water down to a few inches in depth all day without attendance.

It was recognized that the oval shape of the casings greatly weakened their natural strength, but the writer did not anticipate any danger with proper bracing provided the flow of clay and sand through the joints could be prevented. To accomplish this a quantity of dried white pine wedges, tongued and grooved, were procured and as each joint was uncovered it was well caulked with fresh oakum and the wedges driven in with a sledge. The angle braces which had not already sheared off were removed, as it was seen that they could not prevent the casings adjusting themselves to the flow of earth and the dropping of these pieces of iron endangered the lives of men at the bottom. So soon as the 20 ft. of filled in material had been excavated and the weight removed from the bottom the sand again began to flow up from the outside causing the casing and surrounding earth to sink, but bags of concrete were held ready and two layers were quickly spread over the bottom and the water then allowed to rise to remove the pressure and prevent the washing out of cement until the concrete had set.

The brass strainer of the deep well drainage pump was allowed to rest on top of the concrete bags and the next step was to build a concrete bottom 30 ins. high leaving a rectangular compartment around the strainer. Steel plates were then laid over this opening and a 12-in. floor of

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concrete spread, as shown in Fig. 2. The threads and flanges on the suction pipe were to prevent any water creeping along the pipe and causing a leak. A similar piece of threaded pipe 5 ins. in diameter, with flange, was placed in the floor as shown to prevent the water pressure coming on the floor in case of accidental stopping of the pump. A blind flange was provided for this pipe, tapped for a 2-in. and 1-in. pipe to be used later in filling this compartment solid with mortar.

The concrete used was a 1:2:4 mixture made with ¼-in. to 1-in. crushed limestone and mixed with 1½% by weight of Medusa Waterproofing Compound, made by the Sandusky Cement Co. To guard against cracking by expansion ¾-in. twisted rods were placed, as shown in Fig. 2, and spaced 15 in. c. to c.

The concrete forms were made of 2 × 4 in. lagging spiked to circular ribs. They were in 10 ft. lengths and had six segments to the circle. New ribs were required for each section owing to the change in diameter of the well, but the lagging was used repeatedly. As the smallest steel section was not set the diameter at the bottom was large enough to permit of thicker walls than designed. Accordingly, the wall was built not less than 12 ins. at the bottom and this increased to 30 ins. in places where the casing had bulged. The wall was gradually thinned as it approached the top, the last section being 9 in. thick. The floor came about half the distance up the lowest casing and as the forms were the same height as the casings the joints in the concrete wall never came within 5 ft. of the joints in the casings.

Despite all that had been done the joints between the sections continued to leak. Before the concrete was built up past a joint, therefore, it was covered with a strip of tin, leaving a hollow through which the escaping water flowed to a piece of pipe, through the form and into the well.

No night work was done owing to the hazardous nature of this work and the danger to the men in the well, who were compelled to stand below the buckets of concrete as they were lowered. The dampness of the air in the well prevented the concrete from setting very much over night and before recommencing work each morning the joint was carefully washed with neat cement.

The water in the well was allowed to fill up as the concreting progressed and after the work was finished was left standing for six weeks, by which time it was judged that the concrete was sufficiently hardened to stand the pressure of water. The water was then all pumped out and the various pipes in the sides stopped up, starting at the top where there was least pressure.

As no leaks appeared, the flange was then bolted over the 5-in. pipe which had been built into the floor and into this were screwed a 2-in. and 1-in. pipe reaching to the surface of the ground. When all was ready the suction pipe was quickly unbolted at the floor level and a blind flange with lead gasket bolted down. In a few seconds the whole pressure of water was upon the 12-in. slab of concrete covering the chamber in which the suction screen lay but no leak appeared. Mortar was then poured down the 2-in. pipe and finally rammed down until mortar rose in the smaller pipe.

A certain amount of seepage was expected, but this lining after remaining damp several months has finally dried out as white and dry as the concrete above ground and is so hard that a hammer will scarcely make an impression on it

ECONOMIC DESIGN OF REINFORCED CONCRETE.

By F. W. HANNA.*

The economic design of a reinforced concrete slab, beam or girder implies more than the provision of shapes and sizes to resist the assumed acting forces. It involves the selection of the economic percentage of steel reinforcement to be used in forming those shapes and sizes. This economic percentage of metal is not an arbitrary quantity to be fixed by the designer once for all. It is a variable dependent for its value on the relative cost of equal unit volumes of concrete and steel for the particular structure in question.

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The relative cost of steel and concrete for reinforced concrete differs widely for the various parts of the country. In addition to industrial conditions the distance of the construction work from railroad stations, manufacturing centers, sand banks, gravel pits, stone quarries and water supplies all have a marked influence on the cost of the component elements of reinforced concrete. Comparison of different contract prices of the U. S. Reclamation Service for work situated in more or less remote districts in the western part of the United States and comparison of these with prices in other parts of the country show that the ratio of cost of steel and the cost of concrete in reinforced concrete varies between wide limits.

It is the aim of this article to discuss the effect of this variable relative cost of steel and concrete on the economic working stress of the steel and the corresponding percentage of reinforcement. In deriving the relative cost referred to, such expense as does not materially vary with the amount of reinforcement, such as the cost of forms, excavation, handling water and backfilling, should be omitted from the variable cost of the concrete. The cost of concrete and steel as here used is, therefore, the expense incurred in purchasing, transporting, manipulating and depositing the materials in the structure. Moreover, only the effective depth of the beam or slab should be considered, as the depth of concrete on the other side of the steel is not variable with the amount of reinforcement.

For the purpose of stating the problem mathematically let the functions of a beam that are essential to the consideration thereof be represented by the following symbols:

b = breadth of beam.
d = effective depth of beam.
p = ratio of cross-section of steel to cross-section of concrete in the effective portion of the beam.
A = cross-section of concrete in the effective portion of the beam.
c = unit compressive working stress in outside fiber of concrete.
s = unit tensile working stress in steel.
E_c = modulus of elasticity of concrete in compression.
E_s = modulus of elasticity of steel.
$r = \frac{E_s}{E_c}$
M = bending moment.
R = ratio of cost of a cubic unit of steel to that of a cubic unit of concrete.
s = cy.

The cost of a unit length of the beam will be proportional to $bd + RpA$. The problem now resolves itself into finding the value of p, or, which amounts to the same thing, the value of s (since p is a function of s) that will render $bd + RpA$ a minimum. Since c is a constant and s equals cy brevity may be obtained and the same result accomplished by finding the value of y that will render $bd + RpA$ a minimum.

The expression $bd + RpA$ can be expressed as a function of y by use of the following fundamental laws of stresses in beams: (1) The algebraic sum of all the horizontal component stresses equals zero; (2) the moment of resistance equals the algebraic sum of the moments of the internal stresses; and (3) the elongation or compression of any fiber is proportional to its distance, from the neutral axis. It is assumed here also that the deformation curve for concrete in compression is rectilinear and that the concrete offers no tensional resistance.

The resulting equation reads as follows:

$$bd + RpA = \sqrt{\frac{3Mb}{cr}}\left(\frac{r+y}{\sqrt{r+1.5y}} + \frac{Rr}{2y\sqrt{r+1.5y}}\right) \quad \ldots(1)$$

Finding the derivative of this equation with respect to y and equating it with zero, the following equation in terms of y expressing the condition that $bd + RpA$ shall be a minimum is found:

$$(r+3y)y^2 - 2Rr(r+2.25y) = 0 \quad \ldots\ldots(2)$$

The composition of the concrete having been decided upon, its modulus of elasticity may be assumed, which in connection with the modulus of elasticity of steel fixes the value of r. r will here be assigned the value of 10, this being the value used by the writer for 1:2:4 concrete. The cost of reinforcing steel as shown by the records of the U. S. Reclamation Service varies from about 4 to 8 cents per pound, while that of 1:2:4 concrete varies from about 8 to 14 dollars per cu. yd. Supposing the maximum price of concrete to obtain when the minimum price of steel obtains, the relative cost of equal units of volume is approximately 38. On the other hand, assuming the opposite conditions to exist, this ratio is approximately 132. By assigning values to R between these limits and substituting them with the values of r in Eq. (2), the respective values of y may be computed. Subsequently the corresponding values of p may be found by the well known relation stated in the equation

$$p = \frac{r}{2y(r+y)} \quad \ldots\ldots(3)$$

Let the unit compressive working stress for 1:2:4 concrete be assumed to be 600 lbs. per sq. in.; then the economical working stress for steel equals 600 y. Below are tabulated some values of R between the limits above assigned, together with the corresponding approximate values of y, p and s.

Economical Working Stresses and Percentages of Steel Reinforcement for Varying Relative Costs of Steel and Concrete.

R=Cost of Steel÷Cost of Concrete.	$y = \frac{s}{c}$	p = Per Cent of Reinforcing Steel.	s = Max. Stress in Steel, in lbs. per sq. in.*
40	25	0.57%	15,000
50	28	0.47%	16,800
60	30	0.42%	18,000
70	33	0.35%	19,800
80	35	0.32%	21,000
90	37	0.29%	22,200
100	39	0.26%	23,400
110	41	0.24%	24,600
120	43	0.22%	25,800
130	44	0.21%	26,400

*Calculated for c = 600 lbs. per sq. in.
The table is based on $r = E_s \div E_c = 10$.

It may be concluded from this table that, as the relative cost of reinforcing steel to that of concrete increases from 40 to 130: first, the economical ratio of the working stress in the steel to the extreme-fiber stress in the concrete increases from 25 to 44; second, that the percentage of economical reinforcement decreases from 0.57% to 0.21%; and third, that the economical working stress in reinforcing steel for a working stress in concrete of 600 lbs. per sq. in. increases from 15,000 to 26,400 lbs. per sq. in.

From the column of values of s it may be inferred that "medium" steel with a maximum working stress of 16,000 lbs. per sq. in. cannot be economically used with 1:2:4 concrete where the relative cost of steel and concrete exceeds 40. For this grade of concrete, assuming the cost of "high" and "medium" steel to be equal, "high" steel with a working stress of 25,000 lbs. per sq. in. is more economical when the relative cost of steel and concrete is above 40. Although not contained in the table it may be inferred that mild steel can be used economically when the relative cost of steel to concrete is considerably below 40. Of course, the writer is aware that other conditions, such as the amount of allowable stretch, reliability of material, efficient bonding of steel and concrete, etc., often determine the kind of steel to be used, but when these conditions do not prevail the economical reasons above outlined obtain. When the conditions permit, the variation in relative cost may be accomplished by varying the richness of the concrete mixture.

The most important inference to be drawn from the foregoing computations and the one to which the writer wishes to call particular attention, is the low percentage of steel reinforcement required by economical design, where the construction work is located in remote parts of the country as is most of that being conducted by the U. S. Reclamation Service. The maximum value is only about 0.6%, whereas this is ordinarily taken as about the minimum value to use in

districts more favorable to the use of steel. The explanation of this fact is not, however, difficult to find. In addition to industrial conditions, cement alone of the concrete ingredients is enhanced in cost by extra freight charges, while the whole cost of the steel is so affected.

Below is a table similar to the above containing approximate values of y, p and s for other common mixtures of concrete that are of interest and value in the consideration of the economic design of reinforced concrete. In these computations it has been assumed that

r = 12 and c = 550 [for 1 : 2½ : 5 mixtures].
r = 15 and c = 450 [for 1 : 3 : 6 mixtures].
r = 20 and c = 350 [for 1 : 4 : 8 mixtures].

These values, as are those in the previous table, are based on broken stone or gravel concrete made with Portland cement.

Economic Working Stresses and Percentages of Steel Reinforcement for Varying Relative Costs of Steel and Concrete.

R = Cost of steel ÷ cost of concrete.	y = S/c	p = per cent. in steel in lbs. of reinforcing steel.	s = max. stress per sq. in.
(Mixture 1 : 2½ : 5; r = 12, c = 550.)			
20	20	0.94%	11,000
40	27	0.57%	14,900
60	33	0.40%	18,200
80	39	0.30%	21,500
100	43	0.25%	23,600
120	47	0.22%	25,900
(Mixture 1 : 3 : 6; r = 15, c = 450.)			
20	22	0.93%	9,800
40	31	0.53%	14,000
60	37	0.39%	16,600
80	43	0.30%	19,400
100	48	0.25%	21,500
120	53	0.21%	23,400
(Mixture 1 : 4 : 8; 2 = 20, c = 350.)			
20	25	0.80%	8,750
40	36	0.50%	12,600
60	43	0.37%	15,050
80	50	0.29%	17,500
100	56	0.23%	19,600
120	61	0.20%	21,400

THE NEW FOUR-TRACK LINE OF THE ERIE R. R., THROUGH BERGEN HILL, JERSEY CITY.

All the railway lines which reach New York City from the west have to pass through a difficult barrier on the west side of the Hudson River. The ridge of trap rock which borders the Hudson on its west shore and forms the famous Palisades, gradually reduces in height as it comes opposite the lower part of Manhattan Island, but is still of sufficient size to necessitate either tunnels or deep cuttings for railways passing through it. The Central R. R. of New Jersey, which forms the eastern terminal of the Baltimore & Ohio system, alone escapes this barrier by turning to the south and crossing Newark Bay. The Pennsylvania R. R. passes the hill in an open cut; the Erie and Lackawanna railroad lines, which strike the hill half a mile farther north, have each a double-track tunnel through the hill; and the West Shore R. R., three miles still farther north, also tunnels through it to reach its Weehawken terminal.

Both the Erie and Lackawanna railway lines, radiating from Jersey City, but particularly the former, carry an extremely heavy suburban traffic, which has been rapidly growing during the past ten years. Both these roads have for several years been badly hampered in handling this traffic during the rush hours of the day by the limited capacity of their tunnels. The length of the tunnel constitutes a single block, about four-fifths of a mile in length, and a train is not allowed to enter at one end until the train ahead of it has passed out of the farther end. At the eastern end of the tunnel the tracks enter the Jersey City yards, while at the western end there are crossings and diverging tracks; hence trains must enter and leave the tunnel at low speed; and the desirability of making as little smoke in the tunnel as possible puts a limit on acceleration in the tunnel itself. It will readily be perceived, therefore, that 20 to 25 trains per hour is the maximum which can be passed through this tunnel under usual methods of operation.

The Erie has for some years adopted the plan of using both tracks for inbound traffic during the rush hours of the morning, and both tracks for outbound traffic during the rush hours at night, and has, of course, excluded freight trains from using the tunnel during these hours. In addition, it has consolidated two trains in one, in some instances, for movement through the tunnel, dividing them later at the junction of suburban branches where the two trains diverge.

The objections to these temporary makeshifts are, of course, manifest, and the desirability of additional tracks for entrance to the terminals has long been evident to both the Erie and Lackawanna Companies. The latter company is now driving a second double-track tunnel parallel to its present one under Bergen Hill to give the desired added capacity. The Erie Company made plans a number of years ago to remove the roof from its tunnel and convert it into an open cut with four tracks. In this project, however, it met difficulty on account of the streets and the property holders affected on the surface. This section of Jersey City, known as "The Heights," includes some of the best residence property of the city, and there was naturally much opposition to the proposed change. For this and other reasons the Erie has modified its project so that only part of its line will be in open cut, and several sections of tunnel are left to carry important streets above—the natural

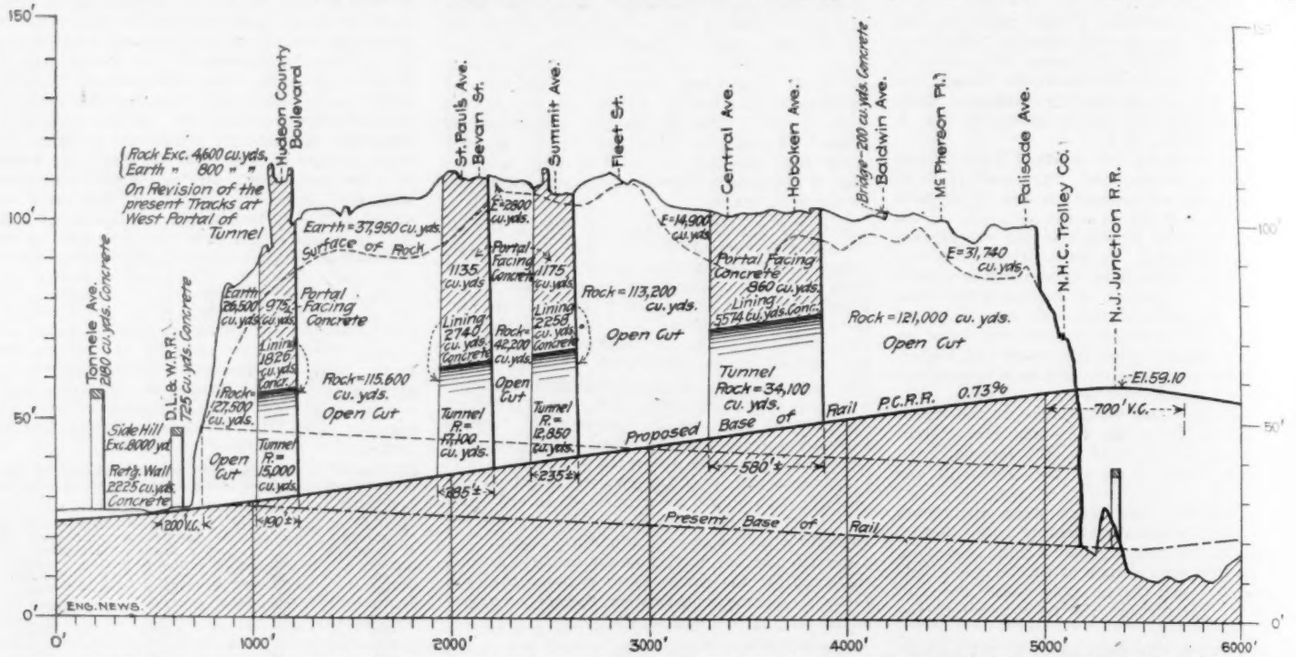

FIG. 1. PROFILE OF OPEN CUTS AND TUNNELS FOR THE NEW FOUR-TRACK LINE OF THE ERIE R. R. THROUGH BERGEN HILL, JERSEY CITY, N. J.

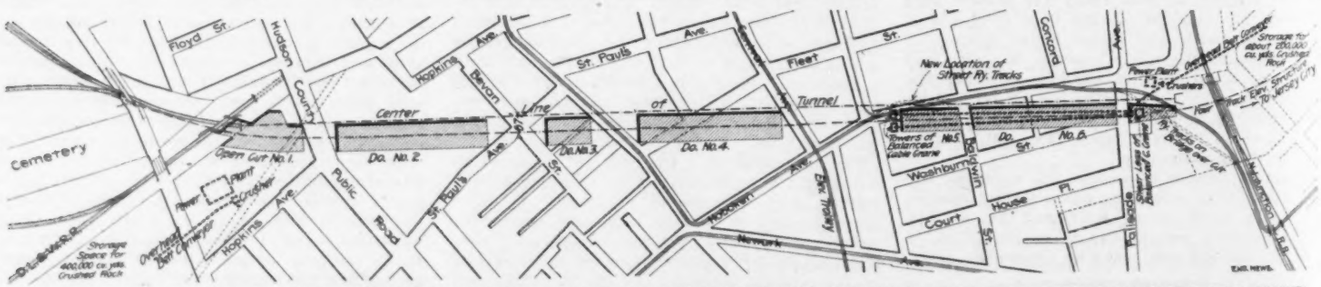

FIG. 2. MAP OF THE PROPOSED OPEN CUTS AND TUNNELS THROUGH BERGEN HILL, SHOWING ALSO THE PROVISION MADE FOR HANDLING THE EXCAVATED MATERIAL.

rock being used for support, in fact, instead of building bridges. The great difficulty or practical impossibility of making an open cut out of the present tunnel while trains are still operated through it, also has caused the alinement to be altered, and the center of the new four-track line will be 67 ft. to the south of the present double-track tunnel and parallel with it.

The Erie also looks forward to elevating its tracks passing through the low-lying portion of Jersey City to the east of Bergen Hill. At the west end, however, it is obliged to keep its tracks at their present level in order to cross beneath the Lackawanna tracks, the tunnel portals of the two roads being located adjacent to each other at the west end. To meet this situation the new Erie track will have a grade of 0.73%, rising toward the east, and will emerge from the hill at an elevation about 40 ft. higher than the elevation of the present tracks. At the east of the hill the tracks will pass onto an elevated structure which will lead to the passenger station at the river front, and this will probably be rebuilt on a higher level.

The accompanying cut (Fig. 1) gives a profile of the new Erie line through Bergen Hill, while Fig. 2 is a plan of its location. The open cuts will be 60 ft. wide at the base and 100 ft. wide at the top. The tunnels will be lined with concrete and the portals will have a concrete facing. The total amount of excavation involved in the open cuts will be about 420,000 cu. yds. of rock and 114,000 cu. yds. of earth, according to the borings thus far made. The excavation for the new four-track tunnel will involve about 79,000 cu. yds.

The contract for the work of excavating the open cuts and tunnels has been let to The Millard Construction Co., of Philadelphia, Pa., and it is expected that about 22 months will be required to complete the work, which is being started simultaneously at several different points. The contractors have already placed orders for over $175,000 worth of new machinery, which is now being rapidly installed.

The top layer of earth will be removed in the ordinary manner by scrapers and steam shovels. For the removal of the rock, however, the contractors are installing a comparatively new system for hoisting and conveying—that made by The Balanced Cable Crane Co., of 135 William St., New York City. This system, which is the invention of Mr. W. F. Brothers, has been used on the rapid transit subway construction in New York City, at the Devonport (England) dock yards, and in the erection of the bridge over the Zambesi River at the Victoria Falls in South Africa. It was described in our issues of Nov. 15, 1900, and May 12, 1904. The plant to be installed for the Bergen Hill excavation, however, is larger by far than any other ever made and involves some important features of novelty. The Millard Construction Co. has purchased six complete balanced cable cranes. Four of these are of short span, and will be installed to operate across cut No. 2 (Fig. 2), and when that is completed will be moved to cut No. 1. The other two cranes have a clear span of 1,300 ft. and will be operated together lengthwise of cuts 3, 4 and 5 (Fig. 2). These cranes will first be used for cut No. 5 and later for cuts 3 and 4 together. The short-span cranes are arranged so that both ends travel on tracks, and they can thus move longitudinally of the excavation to any point desired. Working drawings of these cranes are shown in Fig. 3.

Where the ground is soft, the track on which these cranes travel is anchored to the construction car track on which the dump cars for hauling the excavated material run, by making every fourth tie a long one, as shown in Fig. 3. The long-span cranes have a stationary tower at one end of the cut and two oscillating towers at the other end. The two 1,300-ft. cableways are continuous, as shown in Fig. 4, being supported in grooves on the stationary tower and carried to the oscillating towers, which are counterbalanced at their ends.

As will be found by reference to our previous articles describing these cranes, the hoisting and conveying is done by an electric motor carriage, which travels back and forth on the cableway and is operated by a motorman who rides upon it. An important feature of the balanced cableway system is that the cableway is not fixed by a permanent anchorage at the end, but is free to rise and fall. Thus the hoisting carriage, when at its center, is dropped to a low point requiring but a moderate lift; but as it approaches the oscillating shear at either end, the distribution of load changes and the grade it has to ascend in going up to the dumping point is much less than in any fixed cableway. The practical result obtained is that an astonishingly small amount of power is required to operate the cableways. The electric carriage which does the hoisting and conveying has a hoisting capacity of 5 tons. It can hoist its load at a speed of 80 ft. per minute and travel along the cableway at a speed of 1,200 ft. per minute, yet all six of these traveling carriages require a total maximum of only about 180 HP. of electric current for operation. Their total capacity is calculated to be 3,000 cu. yds. of broken stone in 10 hours.

Turning now to the disposition of the material excavated, it may be mentioned that the rock of Bergen Hill is a hard trap which is in demand for making concrete, macadamizing, etc., as well

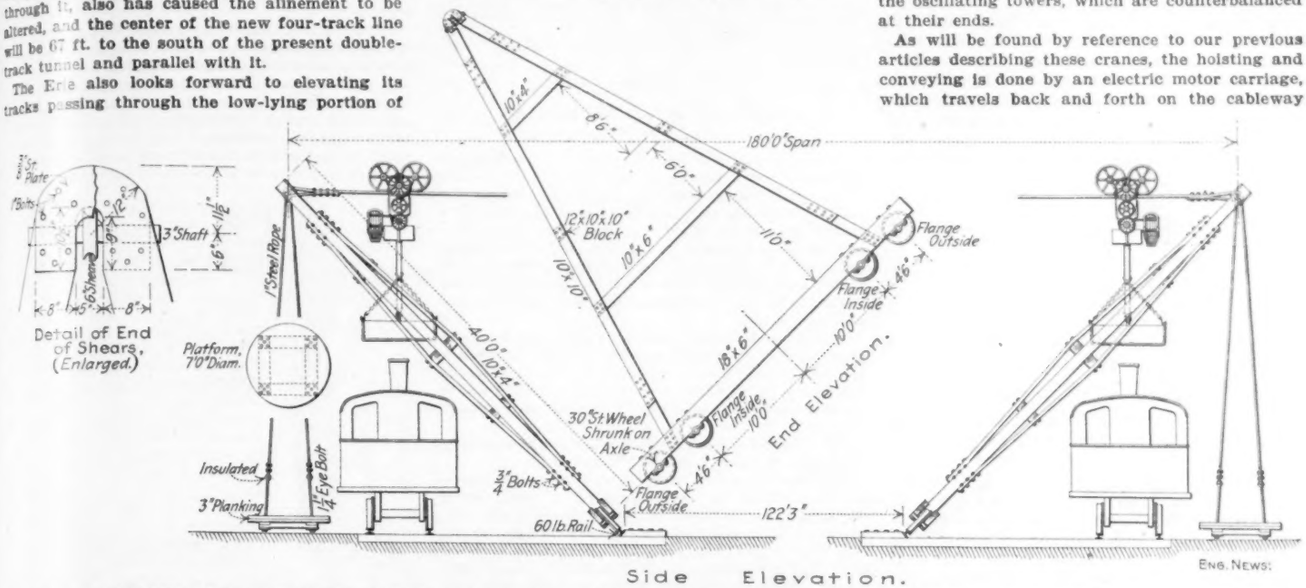

FIG. 3. BALANCED CABLE CRANE OF 180-FT. SPAN, WITH PROVISION FOR LONGITUDINAL TRAVERSE, FOR HOISTING AND CONVEYING ROCK FROM BERGEN HILL EXCAVATION.

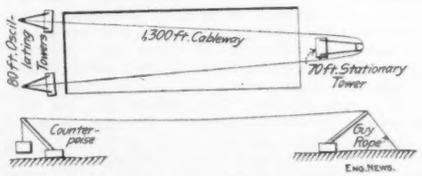

Fig. 4. Diagram Plan and Elevation of the Long-Span Cable Cranes.

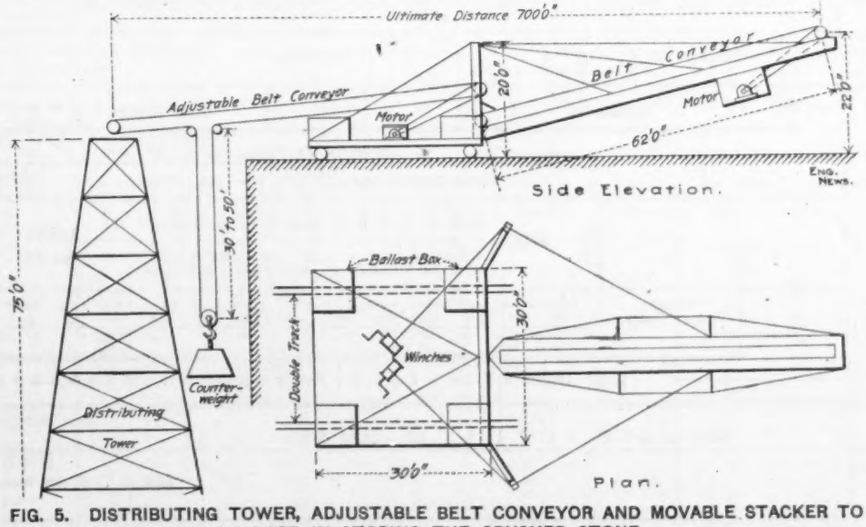

FIG. 5. DISTRIBUTING TOWER, ADJUSTABLE BELT CONVEYOR AND MOVABLE STACKER TO BE USED IN STORING THE CRUSHED STONE.

as for ballast. Two large storage banks are therefore to be created, from which the rock can be taken as needed, and it is to be crushed before placing in these banks. Near the storage bank on the west side of Bergen Hill a large power-house is to be erected by the contractors, and steam boilers of 2,000 HP. will furnish power for the rock crushing done at this point and also for three large air compressors supplying air to 70 drills. The electric generator furnishing current for the electric carriages on the cableways will also be placed here, and also generators for furnishing light to the works. A compressed air main will extend from this power-house clear

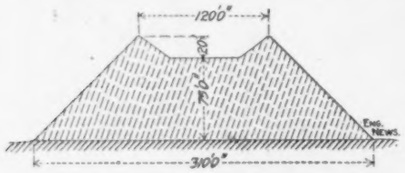

Fig. 6. Section of the Storage Pile.

across the hill, supplying air for drilling, etc., at all points. While the stone will be carried in dump cars from the cranes to the crusher house, it is proposed to deliver it by belt conveyors from the crusher house to the storage piles.

The installation of the entire equipment for the crushing plant and the power plant will be handled by the contractors, the Power & Mining Machinery Co., of Cudahy, Wis., furnishing all the machinery. The crushers are of the vertical gyratory type, there being at the western plant one No. 10 and four No. 6 machines, and at the eastern plant one No. 9 and two No. 6 machines. Three 2,100-cu. ft. cross-compound compressors will supply the air for the drills, and the belt conveyors used will be of the ordinary type employed for handling crushed stone.

The belt conveyors will carry the crushed stone at each end of the cut to a tower about 75 ft. high. Stone will be deposited from each of these towers until a pile has been formed 75 ft. high and of sufficient top area to enable the operation of a 30 × 30-ft. movable stacker. The movable stacker, Fig. 5, will be supplied by the Power & Mining Machinery Co., and by means of an adjustable belt used between it and the tower will be employed for stowing the remainder of the stone.

The storage pile will ultimately be about 700 ft. long and of the sectional dimensions given in Fig. 6. The movable stacker will be provided with eight wheels, two at each corner, which will run on two sets of rails on each side. This is to facilitate advancing the stacker along newly laid tracks without the use of lifting jacks.

As may be seen by reference to Fig. 2, several bridges will have to be built across the open cut in addition to the crossing facilities over the tunnels. One of these bridges at the eastern end will carry two water mains furnishing Jersey City with its water supply.

The whole work of construction is going on under the direction of Mr. G. H. Burgess, Engineer of Terminal Improvements for the Erie Co. The resident engineer on the work is Mr. A. L. Moorshead, with offices at 649 Summit Ave., Jersey City.

ON THE ART OF CUTTING METALS*.

By F. W. TAYLOR,† M. Am. Soc. M. E.

The main object of this investigation has been the thoroughly practical one of enabling us to get more, better, and cheaper work out of a machine shop. The problem before us may be briefly stated to consist of a careful study of the effect which each of the twelve variable elements mentioned in the first part of the address has upon the selection of the cutting speed of the tool.

LIP AND CLEARANCE ANGLES OF TOOLS.—The following are our conclusions regarding the clearance angle of the tool:

(a) For standard shop tools to be ground by a trained grinder or on an automatic grinding machine, a clearance angle of 6° should be used for all classes of roughing work. (b) In shops in which each machinist grinds his own tools a clearance angle of from 9° to 12° should be used.

The following are the conclusions arrived at regarding the angles at which tools should be ground:

(A) Tools for cutting cast iron and the harder steels, beginning with a low limit of hardness, of about carbon 0.45%, say, with 100,000 lbs. tensile strength and 18% stretch, should be ground with a clearance angle of 6°, back slope 8°, and side slope 14°, giving a lip angle of 68°. (B) For cutting steels softer than, say, carbon 0.45% having about 100,000 lbs. tensile strength and 18% stretch, tools should be ground with a clearance angle of 6°, back slope of 8°, side slope of 22°, giving a lip angle of 61°. (C) For shops in which chilled iron is cut a lip angle of from 86° to 90° should be used. (D) In shops where work is mainly upon steel as hard or harder than tire steel, tools should be ground with a clearance angle of 6°, back slope 5°, side slope 9°, giving a lip angle of 74°. (E) In shops working mainly upon extremely soft steels, say, carbon 0.10% to 0.15%, it is probably economical to use tools with lip angles keener than 61°. (F) The most important consideration in choosing the lip angle is to make it sufficiently blunt to avoid the danger of crumbling or spalling at the cutting edge. (G) Tools ground with a lip angle of about 54° cut softer qualities of steel, and also cast iron, with the least pressure of the chip upon the tool. The pressure upon the tool, however, is not the most important consideration in selecting the lip angle. (H) In choosing between side slope and back slope in order to grind a sufficiently acute lip angle, the following considerations, given in the order of their importance, call for a steep side slope and are opposed to a steep back slope: (a) With side slope the tool can be ground many more times without weakening it; (b) the chip runs off sideways and does not strike the tool posts or clamps; (c) the pressure of the chip tends to deflect the tool to one side, and a steep side slope tends to correct this by bringing the resultant line of pressure within the base of the tool; (d) easier to feed. (I) There should be at least a certain amount of back slope. An absence of back slope tends to push the tool and the work apart, and therefore to cause a slightly irregular finish and a slight variation in the size of the work.

FORGING AND GRINDING TOOLS.—The following are the important conclusions arrived at upon the shape of tools as affected by grinding and forging:

(A) The shapes into which tools are dressed and the ordinary methods of dressing them are highly uneconomical, mainly because they can be ground only a few times before requiring redressing. (B) The tool steel from which the tool is to be forged should be one and one-half times as deep as it is wide. (C) To avoid the tendency

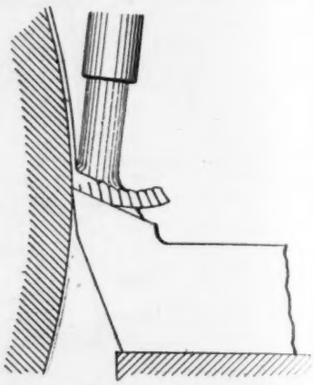

Fig. 1. Diagram Showing Proper Way of Throwing Heavy Stream of Water on Tool to Cool It and Thus Increase the Cutting Speed 30% to 40%.

of the tool to upset in the tool post under pressure of the cut, the cutting edge and the nose of the tool should be set well over to one side of the tool. (D) Tool builders should design lathes, boring mills, etc., with their tool posts set down lower than is customary below the center of the work. (E) In choosing the shape for dressing a tool, that shape should be given the preference in which the largest amount of work can be done for the smallest combined cost of forging and grinding. (F) Forging is much more expensive than grinding, therefore the tool should be designed so that it can be ground: (a) the greatest number of times with a single dressing; and (b) with the smallest cost each time it is ground. (G) Best method of dressing a tool is to turn its end up high above the body of the tool. Tools can be entirely dressed by this means in two heats. The detailed steps in forging a tool by this method are: heating; bending; drawing down the heel; shaping with the chisel; cutting correct height and lip angle; setting over to one side. (H) Fire or heat cracks in tools are due to the following causes: (a) seams or internal cracks in bar of tool steel; (b) nicking and breaking the bar of tool steel while it is cold; (c) failing to turn the tool over and over while heating it for forging; (d) too rapid heating, particularly at the start, in a hot fire. (I) It is of great importance to properly adjust the relative amount of work to be done in the smith shop and on the grinding machine in making the tool: (a) too much work is generally done in dressing tools to exact shape in the smith shop, particularly when automatic grinding machines are used;

*Condensed from the second part of the presidential address delivered by Mr. F. W. Taylor at the New York meeting of the American Society of Mechanical Engineers. The first part of the address was given in our issue of Dec. 6.

†Construction Engineer, Chestnut Hill, Philadelphia, Pa., and Past President of the Am. Soc. M. E.

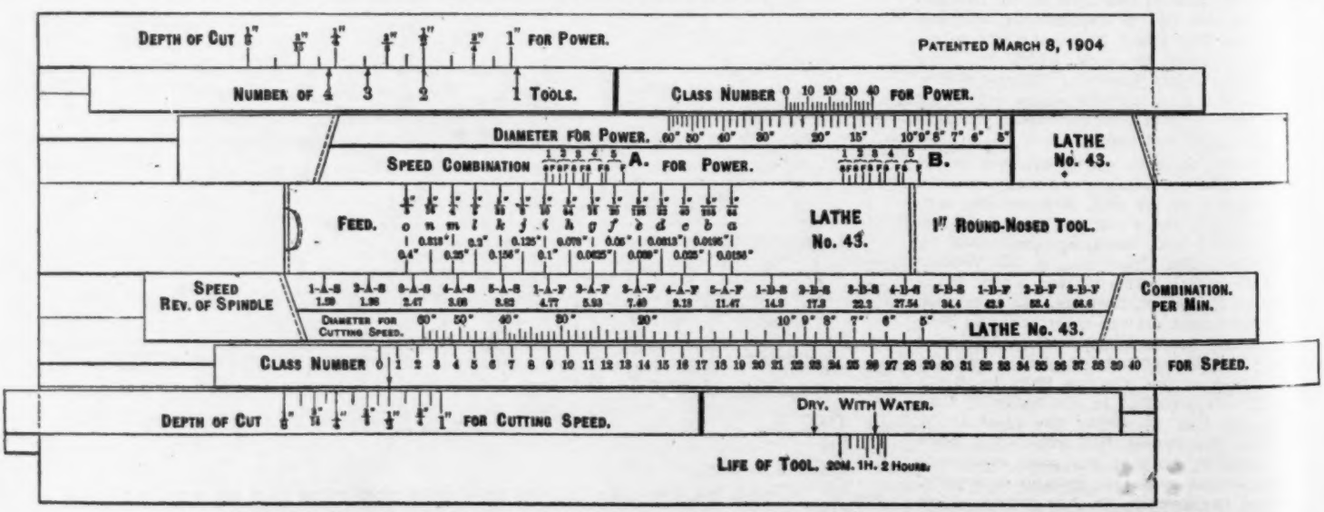

FIG. 2. LATHE SLIDE RULE EMBODYING THE IMPORTANT LAWS DEDUCED IN INVESTIGATIONS ON CUTTING METALS.

(b) limit gage should be used by the smith to properly regulate the proportion of smith work and grinding work in making the tool.

The following are the important conclusions arrived at with reference to grinding tools:

(A) More tools are ruined in every machine shop through over heating in grinding than from any other cause. (B) The most important consideration is how to grind tools rapidly without overheating them. (C) To avoid overheating, a stream of water amounting to 5 gals. per minute should be thrown, preferably at a slow velocity, directly on the nose of the tool where it is in contact with the emery wheel. (D) To avoid overheating where tools are ground by hand or with an automatic tool grinder, the surface of the tool should never be allowed to fit closely against the surface of the grindstone. To prevent this, tools should be constantly moved or wobbled about during the operation of grinding. (E) To lessen the danger of overheating on the emery wheel and to promote rapid grinding, tools should be dressed so as to leave the smith shop with a clearance angle of about 20°, while 6° only is needed for cutting. (F) Flat surfaces upon tools tend far more than curved surfaces to heat tools in grinding. (G) Tools with keen lip angles (i. e., steep side slopes) are much more expensive to grind than blunt lip angles. (H) It is economical to use an automatic tool grinding machine even in a small shop. (I) There is little economy in an automatic grinder for any shop unless standard shapes have been adopted for tools, and a large supply of tools is kept always on hand in a first-class tool room so that tools of exactly the same shape can be ground in quite large batches or lots. (J) Corundum wheels made of a mixture of grit size No. 24 and size No. 30 are the most satisfactory for grinding ordinary shop tools. (K) In grinding flat surfaces, skillful hand grinders invariably keep the tool wobbling about on the face of the grindstone in order to avoid heating.

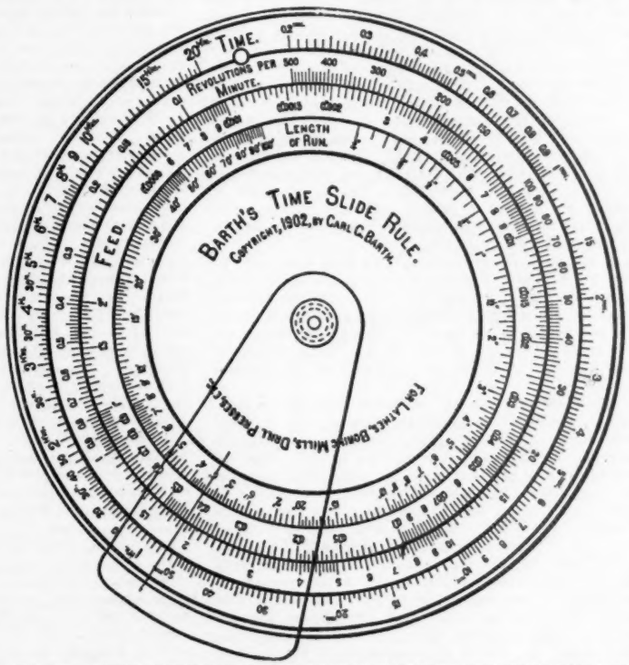

FIG. 3. TIME SLIDE RULE FOR MACHINE SHOP USE, EMPLOYED IN CONNECTION WITH THE LATHE SLIDE RULE IN FIG. 2 FOR DETERMINING THE TIME REQUIRED TO TAKE A GIVEN CUT.

PRESSURE OF THE CHIP ON THE TOOL.—The following are the general conclusions arrived at on this subject:

(A) The total pressure of the chip on the tool in cutting steel of the different qualities experimented upon by us varies between the low limit of 92 tons (2,000 lbs.) per square inch of sectional area of the chip, and the high limit of 168 tons (2,000 lbs.) per square inch sectional area of the chip. (B) In cutting the same piece of steel, the pressure of the chip on the tool per square inch of sectional area of the chip grows very slightly greater as the chip becomes thinner, and is practically the same whether the cut is deep or shallow. (C) Within the limits of cutting speed in common use, the pressure of the chip upon the tool is the same whether fast or slow cutting speeds are used. (D) The pressure of the chip upon the tool depends but little upon the hardness or softness of the steel being cut, but increases as the quality of the steel grows finer. In other words, high grades of steel, whether soft or hard, give greater pressures on the tool than are given by inferior qualities of steel. (E) The pressure of the chip on the tool per square inch of sectional area of the chip depends both upon the tensile strength of the steel and its percentage of stretch, and increases both as the tensile strength and stretch increase; although a higher tensile strength has more effect than a large percentage of stretch in increasing the pressure.

By far the most important conclusion arrived at by us in this field is that the gearing designed in lathes, boring mills, etc., for feeding the tool should be sufficiently strong to deliver at the nose of the tool a feeding pressure equal to the entire driving pressure of the chip upon the lip surface of the tool.

COOLING THE TOOL WITH A HEAVY STREAM OF WATER.—The following are the important conclusions arrived at as to the effect upon the cutting speed of pouring a heavy stream of water upon the cutting edge of the tool:

(A) With high speed tools a gain of 40% can be made in cutting steel or wrought iron by throwing in the most advantageous manner a heavy stream of water upon the tool. In designing slide rules or tables, etc., for assigning daily tasks to machinists a 33% increase in cutting steel or wrought iron should be allowed for instead of 40%, owing to the fact that workmen are more or less careless in directing the stream of water to the proper spot upon the tool. (B) A heavy stream of water (3 gals. per minute) for a 2-in. by 2½-in. tool and a smaller quantity as the tool grows smaller, should be thrown directly upon the chip at the point where it is being removed from the forging by the tool (See Fig. 1). Water thrown upon any other part of the tool or the forging is much less efficient. (C) The gain in cutting speed through the use of water on the tool is practically the same for all qualities of steel from the softest to the hardest. (D) The percentage of gain in cutting speed through the use of water on the tool is practically the same whether thin or thick chips are being removed by the tool. (E) With modern high speed tools a gain of 16% can be made by throwing a heavy stream of water on the chip in cutting cast iron. (F) To get the proper economy from the use of water in cooling the tool, the machine shop should be especially designed and the machine tools especially set with a view to the proper and convenient use of water. (G) In cutting steel, the better the quality of tool steel, the greater the percentage of gain through the use of a heavy stream of water thrown directly upon the chip at the point where it is being removed from the forging by the tool. The gain for the different types of tools in cutting steel is: (a) Modern high speed tools, 40%; (b) old style self-hardening tools, 33%; (c) carbon tempered tools 25%.

CHATTER OF THE TOOL.—The following are the general conclusions arrived at on the subject of chatter of the tool:

(A) Chatter is the most obscure and delicate of all problems facing the machinist, and in the case of castings and forgings of miscellaneous shapes probably no rules or formulas can be devised which will accurately guide the machinist in taking the maximum cuts and speeds possible without producing chatter. (B) It is economical to use a steady rest in turning any piece of cylindrical work whose length is more than twelve times its diameter. (C) Too small lathe-dogs or clamps or an imperfect bearing at the points at which the clamps are driven by face plate produce vibration. (D) To avoid chatter, tools should have cutting edges with curved outlines and the radius of curvature of the cutting edge should be small in proportion as the work to be operated on is small. The reason for this is that the tendency of chatter is much greater when the chip is uniform in thickness throughout, and that tools with curved cutting edges produce chips which vary in thickness, while those with straight cutting edges produce chips uniform in thickness. (E) Chatter can be avoided, even in tools with straight cutting edges by using two or more tools at the same time in the same machine. (F) The bottom of the tool should have a true, solid bearing on the tool support which should extend forward almost directly beneath the cutting edge. (G) The body of the tool should be greater in depth than its width. (H) Chatter is sometimes caused by badly made or fitted gears. (I) Shafts may be too small in diameter or too great in length. (J) Loose fits in the bearings and slides may occasion chatter. (K) In order to absorb vibrations caused by high speeds, machine parts should be massive far beyond the metal required for strength. (L) Chatter of the tool necessitates cutting speeds from 10 to 15% slower than those taken without chatter, whether tools are run with or without water. (M) Higher cutting speed can be used with an intermittent cut than with a steady cut.

HOW LONG SHOULD A TOOL RUN BEFORE REGRINDING?—The following are the principal conclusions arrived at on this subject, regarding the duration of the cut:

(A) For a practical table showing how long each sized tool should be run before being reground, see Table 1. (B) If we note the proper cutting speed for a tool which is to last 20 minutes, and wish to find the cutting speed for a tool to last 40 minutes, multiply the 20-minute cut by 0.92. (C) If we have the proper cutting speed for a tool to last 20 minutes, and wish to find the proper cutting speed for a tool to last 80 minutes, multiply the 20-minute cut by 0.84. (D) For a practical table giving the ratios between the cutting speeds corresponding to different durations of cut, see Table 2. (E) The same relation exists between the duration of the cut and the cutting speed for steels of different degrees of hardness. (F) No scientific or correct conclusions can be drawn from tests in the art of cutting metals in which cuts of much shorter duration than 20 minutes are used. (G) We have been unable to accurately determine the relation between the duration of the cut and the cutting speed for tools used in cutting cast iron. Such laws are badly needed. (H) For the relation of the duration of cut to cutting speed when carbon tempered tools are used, see Table 3. (I) Modern high speed tools do a very much larger amount of work without regrinding than carbon tempered tools.

EFFECT OF FEED AND DEPTH OF CUT ON CUTTING SPEED.—The following are the principal conclusions arrived at on the effect of varying the feed and the depth of the cut upon the cutting speed.

(A) With any given depth of cut, metal can be removed faster, i. e., more work can be done, by using the combination of a coarse feed with its accompanying slower speed than by using a fine feed with its accompanying higher speed. (B) The cutting speed is affected more by the thickness of the shaving than by the depth of the cut. A change in the thickness of the shaving has about three times as much effect on the cutting speed as a similar or proportional change in the depth of the cut has upon the cutting speed. Dividing the thickness

TABLE I.—DATA FROM WHICH TO DECIDE HOW LONG EACH SIZED TOOL SHOULD BE RUN BEFORE BEING REGROUND.

The periods of time given in columns for Redressing, Grinding and Changing Tools, were determined by many stop-watch observations. In the column headed "A" (heavy faced type) are given the equivalent in the time of the machine operator and his machine of the total time for redressing, grinding and setting tool and the tool steel lost each time that the tool is reground.

SIZE OF BODY OF TOOL IN INCHES	TIME TO REDRESS TOOL IN MINUTES	NUMBER OF REGRINDINGS FOR EACH REDRESSING	PROPORTIONATE TIME OF REDRESSING FOR EACH REGRINDING IN MINUTES	A PROPORTIONATE TIME OF REDRESSING FOR EACH REGRINDING CONVERTED INTO EQUIVALENT TIME FOR MACHINE	TIME TO GRIND TOOL IN MINUTES	B TIME TO GRIND CONVERTED INTO EQUIVALENT TIME FOR MACHINE	COST OF TOOL STEEL LOST FOR EACH REDRESSING IN CENTS	COST OF TOOL STEEL FOR EACH REGRINDING IN CENTS	C COST OF TOOL STEEL FOR EACH REGRINDING CONVERTED INTO EQUIVALENT TIME FOR MACHINE	D TIME LOST IN CHANGING TOOL IN MACHINE IN MINUTES	I EQUALS SUM OF COLUMNS A, B, C & D IN MINUTES	T − 7½ TIME TOOL MUST RUN BEFORE REGRINDING IN ORDER TO DO A MAXIMUM OF WORK TIME IN MINUTES	10t TIME IN MINUTES	TIME WE RECOMMEND THAT TOOL BE RUN BEFORE REGRINDING, THAT IS, 10t IN EVEN FIGURES, IN HOURS AND MINUTES
¾ × ¾	8.5	13	0.677	1.130	2.2	3.67	9	0.69	1.38	1.5	7.7	54	77	1—15
¾ × 1	9.2	15	0.613	0.796	2.4	3.00	17	1.13	1.69	1.6	7.0	49	70	1—15
1 × 1	9.7	17	0.571	0.571	2.6	2.60	30	1.76	2.11	1.7	7.7	54	77	1—15
1 × 1½	10.3	18	0.572	0.477	2.8	2.33	47	2.61	2.61	2.8	8.2	57	82	1—30
1 × 1½	11.0	19	0.579	0.414	3.0	2.14	70	3.68	3.16	3.0	8.7	61	87	1—30
1 × 2	12.7	20	0.635	0.353	3.6	2.00	137	6.85	4.57	3.3	10.2	71	102	1—45
1½ × 2	14.8	20	0.740	0.336	4.3	1.95	236	11.80	6.44	3.6	12.3	86	123	2—00
1½ × 2½	17.2	20	0.860	0.331	5.1	1.96	375	18.73	8.66	4.0	15.0	105	150	2—30
2 × 2½	20.0	20	1.000	0.333	6.0	2.00	448	22.40	8.96	4.5	15.5	110	158	2—45

of the shaving by 3 increases the cutting speed 1.8 times, while dividing the length that the shaving bears on the cutting edge by 3 increases the cutting speed 1.27 times. (C) Expressed in mathematical terms, the cutting speed varies with our standard round nosed tool approximately in inverse proportion to the square root of the thickness of the shaving or of the feed. (D) With the best modern high speed tools, varying the feed and the depth of the cut causes the cutting speed to vary in practically the same ratio whether soft or hard metals are being cut.

THE CHEMICAL COMPOSITION OF TOOL STEEL.—The best tool steel should be capable of producing high speed tools of the following qualities or characteristics: (A) Tools should be of such composition that comparatively small errors or imperfections in the heat treatment will not seriously injure them and thus render them irregular in their cutting speeds. That is, the steel should be of that composition from which it is easy to make uniform tools. (B) Tools should not fire crack easily from the heat treatment.

(C) Tools should be capable of running at the highest standard speed in cutting either hard, medium, or soft steel; or hard, medium or soft cast iron. (D) Tools should be difficult to ruin on the grindstone or through overheating in the lathe. (E) Tools should be tough in the body; i. e., not liable to break in use even when receiving severe jars or blows from the work. (F) Tools should be capable of taking fine feeds in cutting hard metals with proportionally high cutting speeds as when taking coarse feeds. (G) Tools should be easy to dress or shape without requiring very high heat. (H) When injured through use in the lathe, the quality of the tool steel should be such that the injury can be repaired by grinding off as small amount as practicable from the tool.

No tool steel has yet been developed which possesses all these qualities in the highest degree. It is, however, a most interesting and useful fact that tool steel having the following chemical composition: Vanadium 0.32; tungsten 17.81; chromium 5.95; carbon 0.682; manganese 0.07; silicon 0.049, possess all except two of these qualities in as high a degree as any steel that we have tested. The two defects possessed by this steel are that it is rather difficult to forge into a tool and it is very tough in its body, although not as tough as tools whose bodies are either annealed or partially annealed.

The improvement in the latest high speed tools over the original high speed tool consists in: (A) Far greater uniformity, owing to less danger in being injured in grinding and in daily use. (B) 50% increase in cutting speed. (C) The attainment of almost its maximum cutting speed without the necessity of the second or low heat treatment. (D) The combination in the same tool of the highest degree of red hardness with a high degree of hardness, thus requiring only one standard high speed tool steel in the shop. (E) The ability, owing to increased hardness, coupled with the necessary red hardness, to make the same proportionate gain when cutting with fine feeds upon hard metals as upon soft. (F) Greater strength in the body.

The only point of inferiority is increased difficulty in forging at a cherry red, and if blacksmiths are taught to forge their tools at a light yellow heat, these tools are easier to forge than the original high speed tools.

SLIDE RULES.—Almost as soon as we had succeeded in developing formulas which represented the results of our experiments, we realized the seriousness and difficulty of the problem before us in endeavoring to make practical and everyday use of these results. The first mathematical solution of the problem was made by Mr. G. M. Sinclair, who devoted, as the writer remembers, a year or more of consecutive work to this end with the help and advice of the writer. This solution was accomplished by means of overlying curves plotted on ordinary cross-section paper, with which we were able to work out laboriously and by a very slow process for each particular lathe or planer, a set of tables which could be used for most of the conditions met with in ordinary work. This method was, however, so exceedingly slow and laborious as to make it far from generally useful.

After Mr. Sinclair left the problem, Mr. H. L. Gantt devoted a year or more of his time almost exclusively to its solution, and it was during this period that we substituted curves laid out on logarithmic paper for the direct curves laid out on ordinary cross-section paper. As a result of this work, we obtained a logarithmic sheet upon which both diagrams and figures were used to represent the laws, and by means of an elaborate cross slide, upon which further elements of the laws were entered, we were able to make a more rapid and much more direct solution of the problem. This was done, however, by the method of trial and error, but by means of this crude sliding table we were able to make quite rapid approximations to the proper working conditions.

It was not until after we began our experiments at the works of the Bethlehem Steel Co. that we finally gave up the hope of obtaining a mathematical solution of this problem through the aid of some of the more noted mathematicians. Mr. Gantt and the writer again attacked the mathematical side of the problem at Bethlehem, and substituted an especially made slide rule accompanied by diagrams, by means of which a still more rapid solution of the problem was obtained. When in this state Mr. Carl G. Barth joined our work, and together Mr. Barth, Mr. Gantt and the writer developed the final slide rule illustrated in Fig. 2, by means of which the problem is directly and very quickly solved This slide rule has since been patented jointly by Messrs. Barth, Gantt and the writer.

In Fig. 3 is illustrated a circular slide rule made by Mr. Barth, which is used in connection with the lathe slide rule, Fig. 2, for quickly figuring the time required to do the work. Both of these slide rules are described by Mr. Barth in his paper, entitled "Slide Rules for the Machine Shop as a Part of the Taylor System of Management," published in Volume 25 of the Transactions.

The writer has already indicated some of the difficulties attending the practical everyday use of these slide rules in machine shops, and has also stated the fact that he has no very great hope of their rapid introduction into practical use. He would add, however, that he looks upon task management as a matter of such great moment, both to the workmen in raising their wages and rendering strikes and labor troubles unnecessary and to the manufacturers in increasing and cheapening their output, that although he has personally retired from the active introduction of this system of management professionally, he is still devoting his time to furthering the introduction of this system, and expects to make this the main object of his remaining life's work. He wishes to state, therefore, that he will be glad at all times to assist through advice any company desiring to work along these lines.

TABLE II.—Practical Rule Showing How Much a High Speed Tool Must be Slowed Down in Cutting Speed in Order to Have It Last a Long Time Without Regrinding.

IF WE HAVE THE PROPER CUTTING SPEED FOR A CUT LASTING	WE FIND THE SPEED FOR A CUT LASTING	BY DIVIDING BY	OR BY MULTIPLYING BY
20 minutes	40 minutes	1.09	0.92
40 minutes	80 minutes	1.09	0.92
20 minutes	80 minutes	1.19	0.84
40 minutes	20 minutes	0.92	1.09
80 minutes	40 minutes	0.92	1.09
80 minutes	20 minutes	0.84	1.19

SCIENCE IN THE FOUNDRY.*

By WILLIAM W. HEARNE.†

The selection of pig iron and its mixing and melting in the foundry are becoming matters of much more interest than formerly. Twenty-five years ago there was not a foundry in the United States that had a chemist in its employ, and scarcely a blast furnace running on foundry iron had a laboratory. Foundry pig iron was bought, sold, and mixed entirely by its appearance and by the experience the foundryman had had with the same brand previously. At that time this was a comparatively safe and satisfactory method to pursue for the reason that the ores and fuel from which each furnace made its product were largely drawn from local sources and the name of the district in which the furnace was located indicated the make-up of the iron.

The great growth of the iron industries since that time, the development of the railway systems, and the increased facilities the railways offer for the assembling of materials, the discovery and development of coking coal fields, the development of the Lake Superior ore fields, and the cheapness with which this ore can be transported on the Great Lakes to widely distant points, have changed the situation entirely. Furnaces in Milwaukee, Chicago, Detroit, Toledo, Cleveland, Buffalo, the Mahoning and Shenango Valleys, in Southern Ohio, in Pittsburg, in Central New York and in central and eastern Pennsylvania can and often do run on almost the same mixture of ore smelted with the same coke.

This makes it necessary for the foundryman to know either the analysis of the pig iron or the ore and fuel that are used.

There are still furnaces, notably in Virginia, that are run exclusively on their own local ores and local fuel. The foundryman who is so fortunate as to be able to obtain this ore does not need to have a laboratory, for he knows from experience exactly how this iron will work and how much of a certain character of scrap this iron will carry to make a certain kind of casting. The fact that these furnaces are comparatively small and are run with a low blast pressure and that the local ore and fuel are almost entirely free from sulphur, all help to make an ideal foundry iron.

The chemistry of foundry practice is one of elimination, and this has been the cause of the almost limitless specifications. The result is that an experiment is made with iron running: silicon, 2.50; phosphorus, 0.80; sulphur, 0.035; manganese, 0.440; and the experimenter discovers that he has made a satisfactory casting. Consequently, when he wants an iron for this kind of work he demands iron of exactly this analysis, not knowing whether or not if he had iron of silicon, 2.00; phosphorus, 1.10; sulphur, 0.05; manganese, 1.25; he would get the same result or possibly a much better and sounder casting, for the phosphorus is if anything a greater fluidizer than the silicon, and the manganese is a powerful oxidizer. When the second iron is melted he would lose at least one-third of the manganese and with it would go the sulphur from his iron and possibly some picked up from his fuel. This will be especially true if he taps his iron from the cupola into a big mixing ladle so as to give the manganese time to act.

The foundry cupola is a very poor thing in which to make a mixture of iron, and very little reaction goes on there beyond the loss of a little silicon and the taking on of some sulphur; besides the slags of most cupolas are too acid and much manganese is lost which ought to be carried forward into the mixing ladle where it could be used to eliminate the sulphur. Not nearly enough lime or fluor-spar is used by foundrymen. If the foundryman would introduce a little fluor-spar to his molten iron, he would be surprised at the amount of sulphur he would smell.

There are three things necessary for a good foundry mixture: fluidity, softness and strength. How is fluidity to be attained? First, by hot melting; second, by the presence in the pig iron of certain alloys, carbon, silicon, phosphorus and manganese, and by freedom from sulphur. Practically pure iron is white and will not run at all but melts into a sponge and burns before it will run.

In ordinary foundry pig iron there is about 93% of metallic iron and about 7% of alloys, and it is the proportion of these alloys to each other that determine the character and grade of the iron.

The real softness of a casting depends on the total amount of carbon and on the proportion of graphitic or free carbon to combined carbon. The real problem is how to get the proper proportion. One sure way is to anneal the casting or to cool it slowly. This is expensive and should be done only when the foundryman has failed to handle his mixture or his pouring properly.

In pig iron the proportion of free carbon to combined carbon depends entirely upon the rate of cooling, and the slightest accident at the time of casting will affect this proportion and will change iron which should be 2X Foundry to 2 Plain or 3 Foundry.

Chief among the foreign elements in pig or cast iron to affect the carbons chemically is silicon. This element has the property of throwing out of solution the carbon in the graphitic form, and many melters seem to think it the only cure for all hard iron. Other things being equal, it is safe to say that an iron carrying 2.50% silicon is a softer iron than one carrying 2% silicon; but silicon is not a softener itself, and acts only by affecting the carbons. An iron with 10% silicon can scarcely be drilled. Pig iron with 4% silicon will not contain as much total carbon as one of 2.50%, as the silicon unites with the iron and robs it of some of its carbon so that a high silicon pig iron never has the dark, open fracture of a 2.50 to 3% silicon iron.

Sulphur is the most dangerous enemy of soft sound castings, as it not only tends to combine the carbon, but by doing this causes the grain to close up quickly and to retain in little holes or sacks gases which might and should escape; in this way it causes the casting to pit and be porous.

If iron can be kept fluid long enough, the sulphur will all rise through the iron and pass off; this can easily be proven by drilling holes in any piece of iron of reasonable size poured in open sand. If three holes are drilled, one above the other, the proportion of sulphur in each

*A paper read before the Mechanical Science and Engineering Section of the American Association for the Advancement of Science, at the New York meeting, Dec. 28, 1906.

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TABLE III.—Relation of Duration of Cut to Cutting Speed.

T = TIME TOOL WAS UNDER CUT IN MINUTES	F = FEED IN INCHES	CUTTING SPEED FROM EXPERIMENTS IN FEET AND INCHES PER MINUTE	CUTTING SPEED BY THE FORMULA IN FEET PER MINUTE $V = \frac{11.3}{f^{0.65}T^{\frac{1}{8}}}$
20	0.050	4'— 8"	4'.35
	0.059	3'—11"	3'.9
	0.084	3'— 1"	3 .1
40	0.050	3'—9"	3 .8
	0.059	3'—6"	3 .4
	0.084	2'—8"	2 .7
80	0.050	3'—3"	3 .3
	0.059	3'—0"	2 .96
	0.084	2'—5"	2 .35

set of drillings will vary as the height. This was demonstrated ten years ago by Guy R. Johnson in a series of a hundred experiments. The problem, then, is to give the sulphur a chance to get away before it is locked in the casting.

There are many ways to do this but the easiest and simplest is by using an iron carrying a fair percentage of manganese with a large mixing ladle. In special cases it can also be done by putting into the mixing ladle a small amount of pulverized ferro manganese, or a small amount of fluor-spar, or a small amount of aluminum; all of these conditions will cause the iron in the ladle to boil, and during this boiling the sulphur will be thrown off and the iron cleaned. Being free from sulphur and having the proper proportion of graphitic carbon, the casting will be soft. Most of the so-called patent fluxes for making semi-steel castings are nothing but pulverized ferro manganese, fluor-spar, and pulverized high ferro silicons. Every foundryman can obtain these alloys himself and make his own fluxes.

Phosphorus and manganese are elements that affect the fluidity of iron fully as much as silicon. Also an iron to have much fluidity must also be low in sulphur. The casting of pig iron in chill molds has very little if any effect on the character of the iron, especially if the foundryman uses a mixing ladle. It does not affect the total carbon at all; if anything it rather increases the amount of this element, for the reason that the surface of the pig iron is cooled quickly, in this way preventing the throwing off of "kish" which is so evident in a cast house when running "hot" iron. It somewhat increases the total combined carbon, owing to the sudden cooling or chilling of the surface, but if the iron contains the proper amount of alloys and is melted hot and tapped into a mixing ladle, the casting will be as satisfactory in every respect as though the pig iron had been sand cast. In addition, the chill casting eliminates one source of trouble, that is, the sand or other dirt in which the sand cast pig iron is run.

A test was made several years ago on a pig of sand cast iron; it was weighed, pickled and then reweighed. By calculation it was found that that particular brand of metal carried 70 lbs. of sand per ton of metal. This amount of additional impurities had therefore to be contended with. In addition it is a fact that iron free from sand melts more quickly than iron coated with it.

NEW STANDARD CAR-WHEEL FLANGE.

A standard form of tread and flange for freight car wheels was adopted in 1886 by the Master Car Builders' Association, and has been in practically universal use ever since. Meanwhile freight car capacity has increased from 40,000 lbs. to 110,000 lbs., and the need for stronger wheel flanges has become plain. While the matter has been discussed at various times by the Master Car Builders' Association, no action was taken until 1904, when specifications for wheels for large-capacity cars were adopted. In 1906, however, the association went further and adopted the new design of wheel tread and flange which is shown in Fig. 1. This action was hastened by the fact that the American Railway Association has a committee investigating the

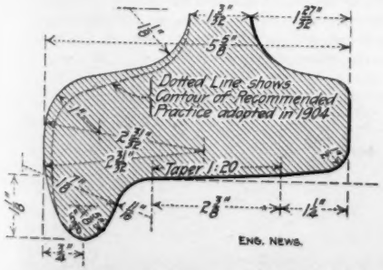


Fig. 1. New Form of Section for Tread and Flange of Freight Car Wheels; Master Car Builders' Association.

question of rail and wheel sections, and it was intimated that the new wheel section would, if adopted by the Master Car Builders' Association, receive the approval of the American Railway Association. If the new section proves as successful and satisfactory as is expected, it will later be adopted as one of the M. C. B. standards, being at present only adopted tentatively as "recommended practice." The three principal changes from the old standard, which is shown in Fig. 2, are as follows:

(1) The thickness of the flange is increased by adding ⅛-in. at the back wheel, the thickness from point to back of flange being ¾-in. instead of ⅝-in., and the radius of back flange being $2^{21}/_{32}$-in. instead of $1^{7}/_{8}$-ins.

(2) This increase in thickness of flange increases the total width of the tire from 5½ ins. to 5⅝ ins., which led to some discussion as to the relation of the thicker flange and wider tire to switches and frogs. The M. C. B. committee, however, took this matter up with the maintenance-of-way members of the committee of the American Railway Association and that committee decided unanimously that a wheel of the new section could be run through the present clearances without difficulty, since the increased thickness at the point measured for gage of track is not more than $^{1}/_{32}$-in. ($^{1}/_{16}$-in. for a pair of wheels), or almost negligible, especially when the variations due to wear of wheels and rails are taken into account. In fact it was shown that locomotives having six and

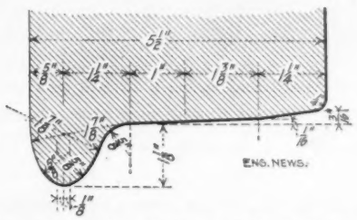


Fig. 2. Original Standard Form of M. C. B. Section for Tread and Flange of Freight Car Wheels.

eight driving-wheels often have some of the wheels set in so as to give a distance of 53⅛ and 53¼ ins. back to back, instead of the M. C. B. standard distance of 53⅜ ins. As these pass switches and frogs without trouble, there should be no trouble with car wheels thickened so as to slightly reduce the distance between the backs of the wheels.

(3) The taper of the tread is increased from 1 in 25 to 1 in 20, this being based on experiments which indicate less flange wear and longer life for the wheel with the sharper taper. The object of the change is to keep the wheel flange a little more free between the rails, thus reducing the wear upon the flange.

(4) The radius of the throat or fillet of the wheel, connecting the tread with the flange, is increased from ⅝-in. to $^{11}/_{16}$-in. This change, however, was adopted as "recommended practice" in 1904, in connection with specifications for 33-in. cast-iron wheels for cars of 60,000, 80,000 and 100,000 lbs. capacity. It has apparently been approved by the committee of the American Railway Association in relation to the rail section to be presented by that committee.

(5) The radius of the edge of the tread is increased from ¼-in. to ½-in.; the sharper edge is more difficult to make and more liable to chip, while it adds to the wheel.

(6) The weight of the wheel is increased about 15 lbs. by the changes.

AUTOMOBILES AS DESTROYERS OF GOOD ROADS.

Within the past few years the enormously increased use of self-propelled vehicles, either as the light, rapid automobile, or as the heavy and slow traction engine, has drawn new attention to the study of the proper design and maintenance of country roads.

With a view toward drawing out the opinion of the profession on this subject, two papers* have recently been presented before the Institute of Civil Engineers, and the voluminous discussions which these papers elicited form the basis for the present article.

The automobile craze has brought three problems to the front: first, the dust problem; second, the speed problem; third, the heavy traffic problem.

Dust, caused by the disintegration of the road surface under wheels and hoofs, has always existed in roads, and has always been more or less of a nuisance. It has never assumed great economic importance until the advent of large-tired motor cars driven at great speed over a dust-laden atmosphere. These vehicles so deluge adjoining houses with dust as to make them uninhabitable. Throughout the United Kingdom there are thousands of heretofore desirable dwellings, situated on or near a highway, for which it is now well nigh impossible to obtain tenants, or if at all, at a greatly reduced rental.

The speed problem is common to all countries, and is one which is probably to be solved more by legal means than engineering aid. The rapid driving of motor cars over a country road involves more than mere danger to the rest of the traffic on the road. The large surface of the tire exposed on the motor car moving at a rapid rate exerts a tearing action on the surface of the road and tends to disintegrate the surface binder. At sharp turns in the highway this skidding of the car in making a rapid turn will invariably cause a weakening of the road at this point.

The very radical attitude that some of the motorists hold as to their right to run at high speed is shown in remarks made by a member of the institute in this discussion. He said: "Motorists at present meet with many obstructions on roads, e. g., live stock and children; and the public needs to learn that the roads are no more safe for live stock than is a main line of railway."

The increasing use in the country districts of England of the old steam-driven traction engine and the more modern motor freight car is having a serious effect on the roads. The heaviest single load which was expected on the old roads was a 10 to 12-ton road roller which, with such a large area of application, acted as a help rather than a hindrance. These new heavy cars carry the same load on four small wheels and consequently demand a much heavier foundation to carry them.

The solution of the three problems offered by the author of the second paper (Mr. Blackwall) is a divided road consisting of two 21-ft. widths separated in the center by a 4-ft. footpath and a wire fence. One of these roads is to be built of exceptionally heavy material, founded quite deep, and is to accommodate all heavy hauling, stock driving, etc., while the other is for the sole use of motor cars and light, rapid vehicle traffic, with no speed limit except at crossings. It is claimed that the action of the heavy traffic grinds and chips the stone into the dust which the fast moving light traffic spreads, so that if the two classes are kept apart, the two contributing causes for the dust nuisance will be separated and the evil cured. The fact that this construction is estimated to cost as much as $12,000 per mile seemed to be no detriment in the eyes of the designer.

Another plan suggested is to build roads exclusively for fast motor traffic connecting the main points over the country, the roads to be reached at a reduced speed along the ordinary country highways. Again the item of cost makes this scheme prohibitory, at least at the present stage of the development of automobile travel. It is thought that the dust problems can best be solved by gradually rebuilding all the roads that give trouble. In the rebuilding special care should be taken in using the hardest and toughest materials, well packed and rolled, and the drainage should be especially looked after. If the dust still gives serious trouble, a coating of tar or oil can be applied to the surface, although this practice is still in an experimental stage in England. A compound known as "tarmac" has been used to a considerable extent, however, and found to give a road which stands up remarkably well under heavy loads, and does not disintegrate so easily as to form dust. It is made by using for a surfacing metal an iron slag which, while still hot from the furnace, has been thoroughly impregnated with tar.

*A Plea for Better Country Roads, by G. R. Jebb, M. I. C. E., and Country Roads for Modern Traffic, by J. E. Blackwall, Assoc. M. I. C. E.

EUCALYPTUS TREES are being extensively cultivated for timber in California. The Atchison, Topeka & Santa Fe R. R. has purchased 9,000 acres in San Diego County, which is being planted with Eucalyptus trees under direction of Mr. E. O. Faulkner, Manager of the Tie and Timber Department.

On account of the proximity of the normal water table to the bottom of the cut, it was necessary to install a permanent drainage system, working by gravity at low tide and automatically switching into an electrically driven pumping station at high tide. The system has proved very efficient.

The second day, Feb. 13, was devoted entirely to the readings of papers by members of the society.

In connection with the work in the New Haven cut described by Mr. Trumbull on the previous day, Mr. C. L. Slocum, of the Bridge Department of the N. Y., N. H. & H. R. R., read a paper on "Bridge Work in the New Haven Cut." All intersecting streets had to be carried across the cut. Three kinds of bridges have been designed. Six plate girder spans are to be built, varying in length from 63 to 75 ft. and in width from 43 to 75 ft. These are all to be built with a longitudinal camber of 6 ins. At one crossing, owing to an extremely complicated system of rail curves and street skews, a double-intersection Warren truss will be erected. All other crossings are to be made with a unique style of reinforced concrete arch in which the reinforcement is principally made up of old rails. Mr. Slocum's article will be abstracted and descriptions of the bridges given later in the columns of this journal.

METHOD OF SEWER ASSESSMENT.

Mr. A. B. Alderson, Town Engineer of West Hartford, presented a paper on the "Charter Oak Sewer System, Method of Assessment." The system of assessment described was divided into the following items: (1) Cost of construction of main trunk sewers, engineering, legal expenses and interest on notes. This is levied on total assessable area in the district and distributed equally among all property holders according to the precise area of their holdings. (2) The cost of a sewer in front of each individual property were a larger size not required on account of accumulation of sewage from other properties. This is applied directly to each property in proportion to its frontage, if a sewer has been actually constructed. (3) House connections laid to curb line at 50c. per lin. ft. and charged directly to the property to be served.

CONCRETE CURBING.

Mr. H. G. Clark, of the City Engineer's Office, Hartford, read a paper on "Concrete Curbing at Park Terrace, Hartford," This stretch of curbing borders a park road which is made up of a continual succession of curves of radii varying from 100 to 1,500 ft. in length, the profile being made up of straight grades connected by parabolic curves. On account of the great number of curves in both planes it was considered easier and cheaper to construct concrete curbing reinforced with the Wainwright rail than to set the usual granite. The relative costs of the two curbings are about 87c. per lin. ft. for the concrete and 98c. per lin. ft. for the granite on tangents and about $1.50 on curves.

ENGINEERING FEATURES OF AN INSANE HOSPITAL.

A paper by Mr. C. E. Chandler on "Some Engineering Features of the Norwich Hospital for the Insane" was next read. This state institution occupies several hundred acres of land on a sandy plateau on the Thames River, about 2½ miles above Norwich. An entire sewer system and water supply, a power plant for heat and light and several new buildings have been recently constructed there.

Mr. Charles A. Ferry read a paper on "Completion and Operation of the New Haven Water Company's Filter Plant." Mr. Ferry read a paper on the design and construction of this plant at the annual meeting of the society in 1905, and the present paper consisted principally of a description of the preliminary sand cleaning methods and of the sand washer used in the regular cleaning of the beds. This filter has been in operation since May, 1906, and a table was given showing a remarkable degree of efficiency, the percentage of bacteria removed never running below 80%, and the average being 92%, while for the last three months the average has risen to 96%, with no single week's record under 90%.

BRIDGE ACROSS CONNECTICUT RIVER AT LYME.

"The New Connecticut River Bridge at Lyme, Conn.," was the subject of a paper by Mr. J. H. Soehrens, Resident Engineer on the work. The new bridge consists of nine piers and two abutments supporting seven double-track, pin-connected, through trusses, 182 ft. c. to c. of end pins; two plate-girder spans 38 and 70 ft. long, and a double-track through truss Scherzer Rolling Lift of 161 ft. span. The distance from base of rail to high water is 25 ft., and between abutments 1,564 ft. On most piers the river bed was dredged out to a depth of about 35 ft. below high water. In this bottom the piles were driven and cut off at about 32 ft. below high water and crushed stone placed between them to the level of the tops. Upon this surface a caisson was sunk. The river bed under some of the piers, however, was bare bed rock, quite rough, 40 to 30 ft. below high water. Crushed stone was dumped in to a depth of about 10 ft., through which piles were driven by a drop hammer. They were sawed off at from 28 to 18 ft. below high water, and additional stone dumped in and leveled off flush with the top of the pile heads. Open caissons were then employed as before. After the masonry was completed these piers were very heavily riprapped.

LAYING SUBMERGED PIPE.

Mr. F. S. Wardwell, of Stamford, described the "Method of Laying Submerged Water and Outfall Sewer Pipe" the laying of about 1,000 ft. of 24-in. bell and spigot pipe weighing 139 lbs. per lin. ft. upon a sandy bottom, the grade of which was considered true enough without preparation. He made all joints of the pipes with hot lead thoroughly caulked, then plugged both ends of the pipe, leaving the outshore end with

FIG. 4. GATES AND SPUR TRACK, FROM UP-STREAM, JUST BEFORE FAILURE.

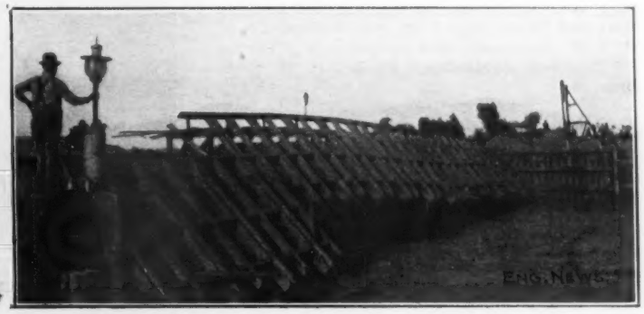


FIG. 5. GATES BEING UNDERMINED AND UPTURNED, AS SEEN FROM ABOVE ON OCT. 11, 1906.

FIGS. 4 AND 5. VIEWS OF ROCKWOOD BY-PASS GATES ON THE COLORADO RIVER CLOSURE WORK BEFORE AND DURING FAILURE.

(Figs 4 to 7, inclusive, Copyrighted by O. W. Peterson.)

Fig. 6. The Gap from Above.

Fig. 7. The Gap from Below.

FIG. 8. THE RUINED GATES FROM BELOW.

FIGS. 6, 7 AND 8. VIEWS OF THE WRECKED ROCKWOOD BY-PASS GATES, COLORADO RIVER CLOSURE WORK.

(The upper railway trestle in Figs. 7 and 8 was above and parallel with the gates. Fig. 7 is a view taken just below and looking through the lower trestle, which was at an angle of 45° with the gates.)

NOTES ON CLOSING THE BREAK IN THE COLORADO RIVER.

We give herewith a pictorial record of some phases of the work of closing the break in the Colorado River, Southern California. Figs. 1 and 2 show the general status of the main closure work on Jan. 25, 1907. Two days later the gap in the trestle work had been closed, track had been laid and rock was being dumped to close the break. On Feb. 5, rock was being dumped from each of the two trestles. On Feb. 9 a head of water of 11 ft. 2 ins. had been obtained above the closure work. A press dispatch, dated Feb. 11, stated that the break had been closed and the levee repairs and extension were being pushed.

As can readily be understood, pile-driving for the trestle was conducted with difficulty, since water was passing through nearly the whole length of the break while the work was in progress.

The levee indicated at the left end of Fig. 1 runs down-stream for 7,000 ft. This old length of levee, which was damaged by water passing beneath it at the time of the break in December, 1906, is being reconstructed, and the levee is now being extended about eight miles.

Figs. 3 to 8 picture the Rockwood by-pass gates; Fig. 3, during construction; Fig. 4 in the morning of the day of their failure (Oct. 11, 1906); Fig. 5 during the failure, and Figs. 6 to 8 after the failure. These gates constituted the fifth attempt to close the break in the Colorado River (see Eng. News, Dec. 27, 1906, for maps and other details). They were built on dry land in the angle between the old and new river channels, with the idea of by-passing the flow through the new channel so the latter could be permanently closed. They had been completed, the by-pass channel to and from them had been dredged, enough rock had been dumped in the near-by break to give a head of 5.8 ft. against the closure works, and the entire flow of the river was passing through the gates, when a rise in the river brought drift to the gates. This choked the gates and caused a scour above and below them. The trestle shown by Fig. 4 was hastily thrown across the by-pass, just above the gates. This trestle bore a spur track from the northerly earth portion of the closure works. The track was designed for use in dumping rock in front of the gates, for their protection, and also to close and fill in the gates with rock. Just as the spur was completed, at 3:30 p. m., Oct. 11, 1906, the gates failed, as shown by the view, Fig. 5. The upper toe of a portion of the gates rose a foot or so in a bow-shaped form. After some two minutes a rise of several feet more occurred, followed by a further rise, until the upper toe, it is said, was 10 or 15 ft. above the water surface. The upper row of sheet piling fell in beneath the gates, drift appeared below, and after a brief interval of rest on the down-stream toe the wrecked portion (120 ft. in length) fell back into the water and floated down-stream for 150 ft. This section, or a part of it, appears to be shown in the views, Figs. 7 and 8.

Following this disaster the water held back by the gates and the embankment rushed through the gap in the gates. The trestle above the gates was weakened by the rush of water. The main trestle, below the gates, lost two bents by the debris washed against it, while five other bents were weakened thereby. The north bulkhead of the gate was weakened by the scouring of the water and the portion of the gates remaining in place began to settle. The gates were therefore abandoned, and the by-pass was subsequently closed by building a rock-fill dam, as described in our issue of Dec. 27, 1906, already mentioned. This dam stood, but a portion of the other closure work failed soon after being brought to an apparently successful issue, early in December, 1906, as stated briefly in the editorial pages of our issue of Jan. 3, 1907.

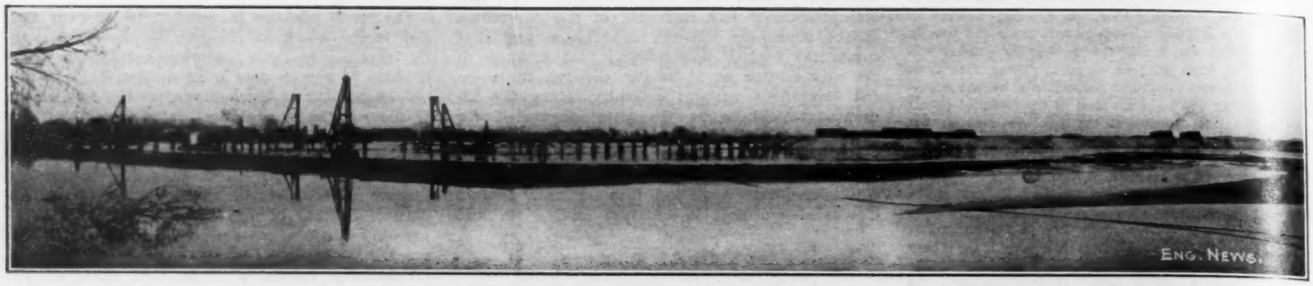


FIG. 1. GENERAL VIEW OF NEW CLOSURE WORK, COLORADO RIVER BREAK, JAN. 25, 1907.
(The south end of dam that effected the December closure is at about the point where the two locomotives are shown.)

ANNUAL MEETING OF THE CONNECTICUT SOCIETY OF CIVIL ENGINEERS.

The 23d annual meeting of the Connecticut Society of Civil Engineers was held at Hartford, Conn., on Feb. 12 and 13. There were over 100 members in attendance. In addition to the business sessions the members of the society

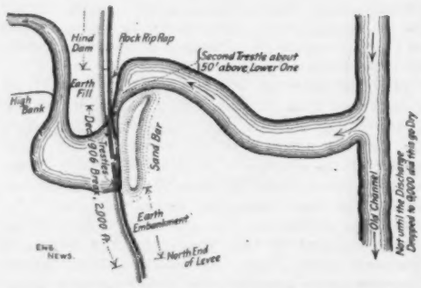


Fig. 2. Sketch Plan of Closure Work, Colorado River Break, Jan. 25, 1907.

were guests at a luncheon tendered by the Hartford members, and a very enjoyable banquet was held at the Hartford Club.

The reports of officers showed the society to be in a very prosperous condition, with 275 members and a balance in the treasury of $782.91. The following officers were elected for the ensuing year: President, Mr. D. S. Brinsmade, M. Am. Soc. C. E.; 1st Vice-President, Mr. E. W. Bush, Assoc. M. Am. Soc. C. E.; 2d Vice-President, Mr. F. T. Estabrook; Secretary and Treasurer, Mr. J. F. Jackson, and the Board of Directors, Messrs. H. J. Kellogg, G. K. Crandall, J. K. Punderford and C. F. Chase. On account of the illness of Mr. Brinsmade, Mr. C. F. Chase, president for the past year, presided.

The principal address of the first day's session was made by Prof. Lewis M. Haupt, M. Am. Soc. C. E., of Philadelphia, on "Epochs of Transportation." Mr. Haupt held that the growth of the country, with the consequent increase of traffic is much greater than the increase of transportation facilities, and that the only solution to the problem is the proper construction of canals and the development of harbors to provide for coastwise shipping. He also thought that a reversion to past practice should be made in the building and maintenance of canals by private companies, operated under a governmentally controlled toll-rate. The lecture was illustrated by many lantern slides.

THE NEW HAVEN CUT.

This talk was followed by an illustrated paper on "The New Haven Cut," by Mr. John F. Trumbull, Assistant Engineer of Construction on the work. The New York, New Haven & Hartford R. R. passes through New Haven in a depression, the lowest portion of which is but 1 ft. above mean high water. The cut now carries for the most part two main line tracks with occasional four-track lines where branches occur.

On account of the extremely heavy traffic at this point, which is commonly called the "throat of New England," a four-tract road has been designed and is now in course of construction. This four-tracking necessitated the removal of many buildings, excavation of the ground on which they stood to the level of the old cut, construction of temporary bridges to carry streets across the cut, construction of the final bridges and retaining walls, and last of all the track work. All the work has to be carried on with the whole main line traffic of the railway passing through the cut. There is 350,000 cu. yds. of excavation and 80,000 cu. yds. of concrete work in the improvement.

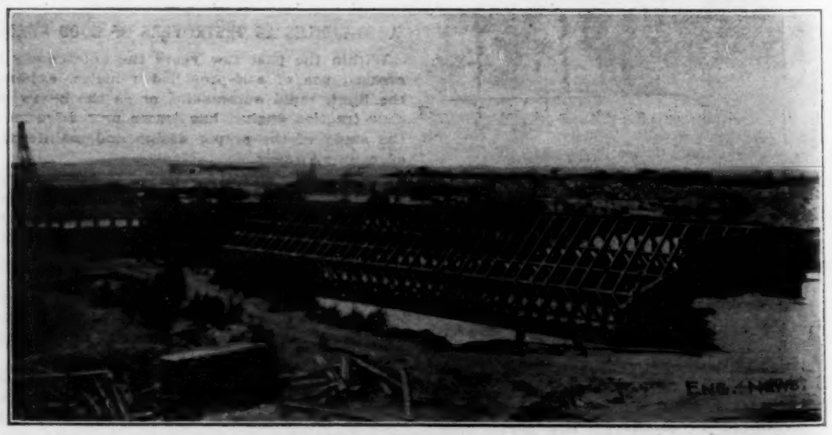


FIG. 3. ROCKWOOD BY-PASS GATES UNDER CONSTRUCTION, BEFORE BY-PASS WAS DREDGED.
(These gates on the Colorado River closure work failed on Oct. 11, 1906.)

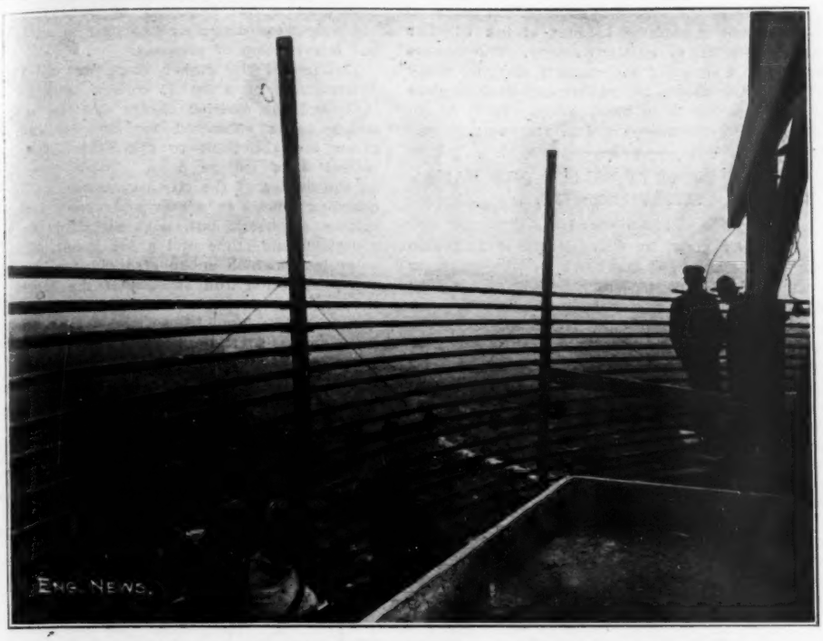


FIG. 3. VIEW SHOWING REINFORCEMENT OF ATTLEBORO STAND-PIPE.

first 60 ft. of the height there were two rows horizontally, varying in vertical spacing from 4 ins. at the bottom to 8 ins. at the top. Above the 60 ft. level there was but one horizontal row of bars, the vertical spacing being about 5 ins.

It was at first intended to use cold twisted square bars, but on account of the difficulty in bending them around the circle of the tank plain rounds were substituted.

In the original design ⅝-in. rounds were to be used as vertical rods, but on account of their instability, as found in the first 7 ft. of the work, it was decided to use channels, 15 in the circle of the tank, with their webs placed radially and the flanges drilled at the proper intervals for the reception of short lengths of ½-in. bars on which the horizontal reinforcement was hung inside and outside of the channels.

CONSTRUCTION.—After the foundation proper was laid, a timber bent tower 60 ft. high was erected in the center of the stand-pipe, independent of the construction, and a derrick placed on top. From this all handling of materials was carried on. The forms were built as two complete circumferences, each 7½ ft. high, to be alternately removed and placed one above the other. The work progressed in the following order: first, the steel for the 7½-ft. rise was erected, then the forms, which were in twelve lengths to a circumference and locked together with iron clamps. These forms were lagged in vertical lines on the outside for the whole 7½ ft., but were lagged horizontally on the inside as the concrete progressed, thus allowing more ready access to the wall. They depended solely on friction for their hold to the wall. When the top of the 7½-ft. section was reached, a series of beveled 2 × 3-in. strips of wood was placed in the new concrete, to be taken out as it partially hardened. The holes thus left, together with steel doweling pins, were considered sufficient to bond together the old and new work, provided that the old surface had been previously cleaned thoroughly from all dirt, laitance, etc.

The work so progressed for the first 60 ft., after which the interior tower was raised to the total height used, and the stand-pipe finished from this new position. No attempt was made to make an entirely monolithic structure by continuous concreting, but work was carried on at four places at once on each 7½-ft. ring, and great care was exercised in cleaning the old work before beginning the new. As no leaks have developed at the juncture of new work and old it seems safe to say that the method of joining was all that could be desired and that the structure has become a monolith.

As a result of experiments and their own experience, the contractors determined that a mortar made of one part cement and two parts sand was impervious to water, and that concrete approximating a 1:2:4 mixture, but with from 5 to 10% excess of mortar over voids in the stone, would also be waterproof. This mixture was used in the construction of the side wall, a small aggregate being necessary in order to completely fill the wall between the reinforcement.

In addition to the ordinary water pressure the stresses in the stand-pipe were computed to take into account the pressure of ice. It was arbitrarily assumed that the ice would give an additional tension of 30,000 lbs. per ft. of height on the concrete from top to bottom.

As a matter of interest it may be stated that the 1:2:4 concrete in the walls cost, approximately, as follows:

	Per cu. yd.
Cement	$4.80
Sand and stone	3.90
Mixing concrete	.40
Placing concrete	2.20
Form work	2.65
Total	$13.95

Bending and placing steel cost about $9 per ton, or $2.30 per cu. yd. of concrete.

WATERPROOFING.—When the concrete had reached a height of 20 ft. water was turned into the pipe and thereafter during the whole construction a head of water some few feet below the lowest form was maintained. A few minor leaks appeared as the work progressed, none of which were other than a mere surface wetting, until at about 100 ft. there were noticed three small pin-head leaks, the only ones that spurted the water beyond the wall. These latter soon ceased. Up to this time no surface waterproofing had been applied, but winter was setting in and the water supply being needed it was decided to use the stand-pipe until the following spring without further waterproofing.

When the work of waterproofing was started in the spring, there had appeared in the outside lower 15 ft. of the pipe several places where leakage had occurred to such an extent as to scale off the surface concrete. This was due, no doubt, to the frost action in a very small seepage or leakage plane. At these points the surface concrete was taken off, reinforcing clips attached to the circular rods already in place and an entirely new surface applied.

The first coat of waterproofing applied was a 1 to 1 mixture of sand and cement, with 2%

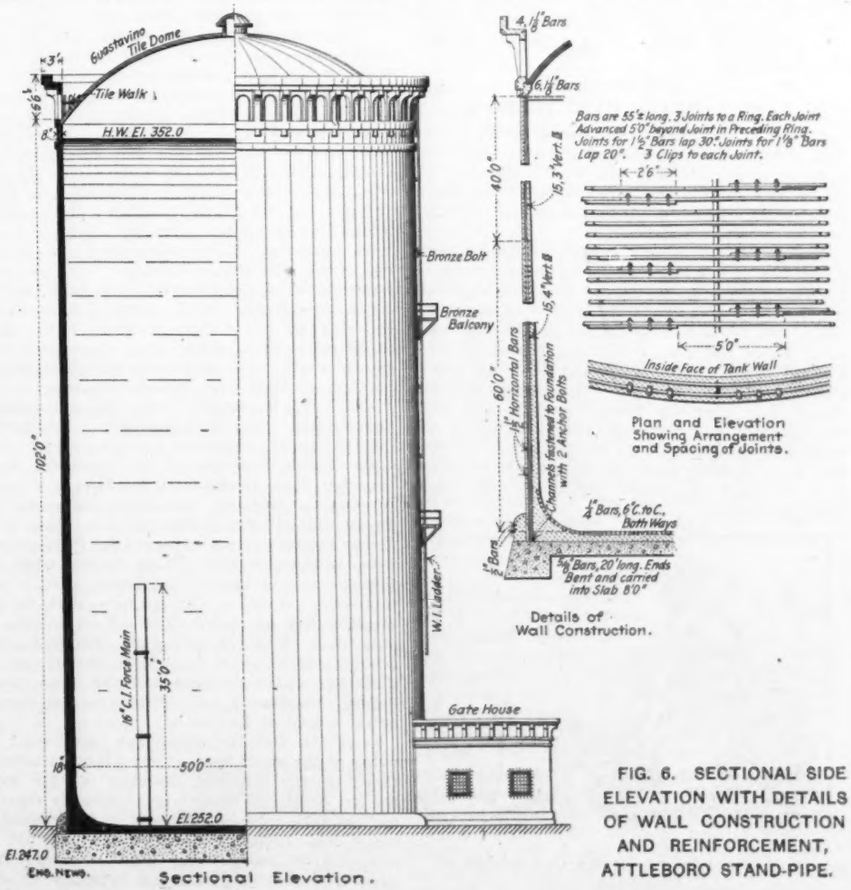

Guastavino Tile Dome
Tile Walk
H.W. El. 352.0
Bronze Bolt
Bronze Balcony
W.I. Ladder
16" C.I. Force Main
35'0"
50'0"
El. 252.0
El. 247.0
Gate House
ENG. NEWS.
Sectional Elevation.
4 1/8" Bars
6 1/8" Bars
Bars are 55'± long, 3 Joints to a Ring. Each Joint Advanced 5'0" beyond Joint in Preceding Ring. Joints for 1⅛" Bars lap 30". Joints for 1⅛" Bars Lap 20". 3 Clips to each Joint.
2'6"
5'0"
Inside Face of Tank Wall
Plan and Elevation Showing Arrangement and Spacing of Joints.
Channels fastened to Foundation with 2 Anchor Bolts
1" Bars, 6" C. to C., Both Ways
⅝" Bars, 20' long. Ends Bent and carried into Slab 8'0"
Details of Wall Construction.

FIG. 6. SECTIONAL SIDE ELEVATION WITH DETAILS OF WALL CONSTRUCTION AND REINFORCEMENT, ATTLEBORO STAND-PIPE.

augur holes to govern the sinking. He then lashed 126 empty barrels at regular intervals along the pipe, and on the high tide towed the line to place, and starting at the inshore end cut away the castings to the barrels in progressive order. The pipe was dropped in one minute and has stood all inspection tests.

Two more papers were presented which will be abstracted in early issue of Engineering News. They are "Some Tests in Sighting and Leveling Rods and Stadia Rods," by Prof. John C. Tracy, of Yale University, and "Transverse Contours for Roadway Pavements," by Mr. H. H. Gladding.

REINFORCED CONCRETE STAND-PIPE AT ATTLEBORO, MASS.

Among the later and less universal uses of reinforced concrete is the stand-pipe for the water supply of towns. We have noted in this journal (Dec. 29, 1904, p. 596), the stand-pipe at Fort Revere, Mass., and (Feb. 25, 1904, p. 184), the one at Milford, O. There has also been built within the last year at Waltham, Mass., a water tank of reinforced concrete, 100 ft. in diameter and 37 ft. high. These three, together with the one described in this article, are the only ones of any size known to have been built. The peculiar conditions under which the designer works in this case and the uncertainty of the result owing to so few precedents have, no doubt, made engineers hesitate to undertake their construction.

The two great problems in the design of a stand-pipe are, first, to insure strength to resist the water pressure, and, second, to make the structure waterproof. The two are somewhat interdependent, particularly in a concrete structure, where a protracted leakage would be sure to endanger the strength of the material. In a non-elastic material like concrete, the immense pressure at the bottom of a 100 ft. column of water makes the tendency to expand and open cracks in the side walls a dangerous possibility, and the proper reinforcing of these side walls together with the right kind of waterproofing

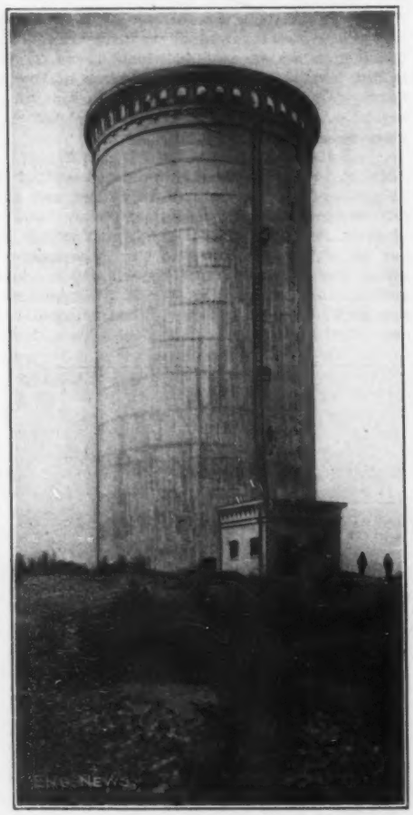


Fig. 1. View of Reinforced Concrete Standpipe, Attleboro, Mass.

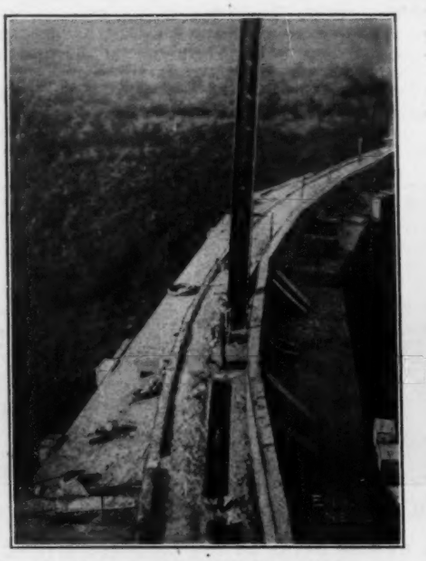


Fig. 4. View Showing Joint Between Courses in Wall of Reinforced Concrete Standpipe.

are the things toward which the designer's efforts bend.

The town of Attleboro, Mass., was supplied with water up to the spring of 1904 from a wrought-iron stand-pipe 30 ft. in diameter and 125 ft. high, holding some 600,000 gals. of water. In March, 1904, a break in the line immediately after a fire, showed the authorities the necessity of building another and larger storage reservoir for the water, one holding at least 3,000,000 gals. if possible. There was no space nor location for a reservoir of such a capacity, but an extremely convenient location for a stand-pipe was available. Owing to difficulties in design, however, it was decided to build a stand-pipe of only 1,500,000 gals. capacity.

The water of Attleboro, though of excellent quality for both domestic and manufacturing purposes, contains carbon dioxide in such quantities as to attack wrought iron and steel, causing a great deal of rust to accumulate and necessarily diminishing the life of an iron stand-pipe. It was estimated that nearly two tons of rust was taken out of the old stand-pipe annually.

For the following reasons, therefore, it was decided to construct a reinforced concrete stand-pipe: (1) The lowest side plates in a steel stand-pipe of the size required (50 ft. diameter and 100 ft. high) were computed to be 1¾ in., which is the thickest plate rolled by any of the steel companies and a special with most. (2) The carbon dioxide would have no effect on concrete, and thus would obviate the difficulty of removing rust and also the danger of any of the corroded material getting into the mains and thence into house connections. This then reduces the costs of maintenance of the concrete structure to almost nil. (3) The life of a reinforced concrete structure is, barring untoward accidents, without limit, whereas, it was found that steel stand-pipes have to be replaced about every 20 years. (4) It was found that the reinforced concrete structure ran about $3,000 lower in cost than the steel.

Bids were therefore asked on a reinforced concrete stand-pipe, the general dimensions and connections to the city being all that were specified, the bidder to furnish his own design as to method of reinforcement and construction. In September, 1904, the contract was awarded to the Aberthaw Construction Co. of Boston, Mass.

The structure as built is 50 ft. in diameter, 106 ft. high from the elevation of inside of bottom of tank to the top of cornice, with walls 18 ins. thick at the bottom and 8 ins. thick at the top, the batter being taken up in the outside walls. The inlet pipe rises to 40 ft. above the bottom and the water is compelled by check valves to leave the tank through a 24-in. pipe in the bottom, thus insuring circulation. Above the top cornice openings are made all the way round the tank, affording a uniform exit for the water in case of overflow, so that no washing of the concrete can occur at any one place. On one side rises a wrought-iron ladder, held in place by bronze bolts.

The foundation, which was on good solid hardpan, was of 1:3:6 concrete 4 ft. deep

Fig. 5. View Showing Inside and Outside Forming of Side Walls; Reinforced Concrete Standpipe.

on edges and 18 ins. under the floor proper, and reinforced with ¼-in. bars spaced 9 ins. c. to c. vertically, and ⅜-in. bars 12 ins. c. to c. horizontally. On top of this foundation the bottom of the stand-pipe, 1 ft. thick, was commenced and carried in a continuous piece of work around the sides and up into the side wall. The reinforcement of this bottom consisted of ¼-in. bars spaced 6 ins. c. to c. and crossed both ways horizontally, these bars turning up into the side wall for a distance of about 2½ ft. The reinforcement of the outer wall consisted of round bars varying from 1½ ins. at the bottom to 1¼ ins. at top, some 36 ft. long, joined together with 18 ins. lap, taking thus three lengths of bar to complete the circumference. Care was taken that no two splices in any horizontal ring came in line, and in one vertical line there was but one splice in eleven bars. For the

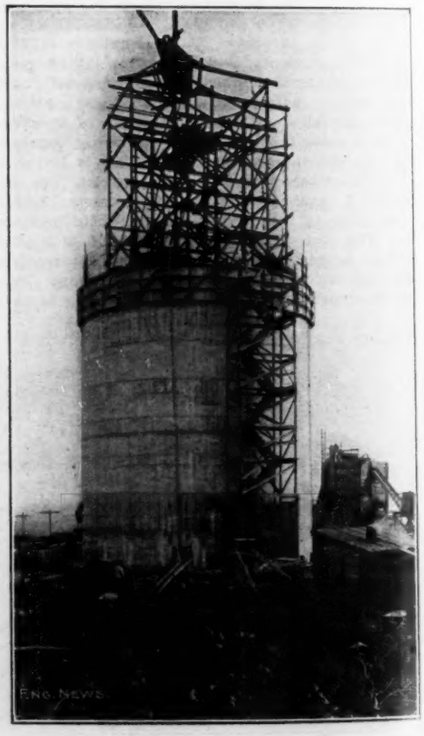


Fig. 2. Reinforced Concrete Standpipe Partly Built, Showing Method of Construction and Forming.

of lime added. Then three coats of straight 1 to 1 sand and cement were applied, each coat being scratched and marked for the proper bonding of the next coat. After the application of these coats there still appeared the same surface wetting noticed before. It is to be understood that at no time was the seepage so great as to be dignified by the name of leaks, and had the stand-pipe been built in a non-freezing locality there would have been no further efforts to waterproof. In order to prevent the expansion and consequent damage due to the freezing action of the water it became necessary to apply another method of waterproofing.

This last surface was made by the "Sylvester process," described as follows:

> Thoroughly clean and dry the wall, then apply, boiling hot, a pure Castile olive-oil soap solution, 12 ozs. to 1 gal. of water; 24 hours later, when wall is dry, apply a solution of alum (2 ozs. to 1 gal. of water) at normal atmospheric temperature.

These soap and alum washes alternated for four coats of each. This last coating has apparently solved the waterproofing problem, as Mr. Snell, the superintendent of the water-works, says, in a letter of Dec. 13, 1906:

> I am pleased to say at the present time there are no visible leaks, and the commissioners have accepted the stand-pipe from the contractors as being water-tight. There has been no indication of trouble from freezing either inside or out up to the present date.

In conclusion, the engineers decided that in such a stand-pipe it is useless to attempt an impermeable wall. The ideal concrete stand-pipe should be built of a rich, small aggregate concrete, thoroughly tamped and compacted, reinforced with a low elastic limit steel to permit of a more equal expansion of steel and concrete, and coated inside with an independent and extremely elastic skin of waterproofing.

In the "Journal of the New England Water-works Association" for September, 1906, this stand-pipe is the subject of a paper by Mr. George H. Snell, Superintendent of the Water Department of Attleboro. The paper is followed by a discussion by Mr. F. A. Barbour, M. Am. Soc. C. E., who was the consulting engineer on the work, and Mr. L. C. Wason, M. Am. Soc. C. E., president of the contracting company which built the pipe. The material for this article is mostly taken from the above-named journal.

DRAFTSMAN'S PEN-FILLING INKSTAND.

The pen-filling inkstand shown herewith is designed for the convenience of the draftsman. It enables him to fill his pen by the use of one hand alone, in a simple and rapid manner; the other hand is thus free to hold the tee-square, triangle, etc., as occasion requires.

The method of using the device is as follows: With the pen held precisely as when ruling a line, place the hand on the rest provided, depressing and holding it firmly at the limit of its movement, and bring the pen directly under the dipper. Raise the pen until the dipper loop has entered between the blades, and move the hand slightly so that the loop will just touch both blades, one after the other, when the pen will fill instantly. No attempt should be made to draw the loop through the blades, but lower the pen, move it aside, and withdraw the hand from the rest, when the rubber cap will descend and close the bottle.

A Pen-Filling Inkstand for the Convenience of Draftsmen.

The form of the dipper is such that it picks up and delivers a uniform amount of ink whether the bottle is full or partially empty. The makers state that a series of experiments covering many months have shown the rubber cap used to close as is the cork now in general use. Theo. Altenheder & Sons, Philadelphia, Pa., are the makers.

A NOTABLE DINNER OF THE NEW YORK WATER SUPPLY ENGINEERS.

[Contributed.]

The dinner given by Chief Engineer J. Waldo Smith to about 400 members of the engineer corps of the Board of Water Supply of the City of New York, on Friday evening, Feb. 8, as a personal expression of his appreciation of the vigor and of the spirit in which their work of survey and investigation had been carried on during the past year is especially worthy of note for the emphasis that it placed on co-operation, loyalty to the job, and guarding against petty jealousies and misunderstanding in a large engineering organization.

The dinner was made notable also by the presence of the city's chief officials: the Mayor, the Comptroller, the Corporation Counsel, the Municipal Civil Service Commission, a majority of the members of the State Water Supply Commission, who plainly took a new measure of the magnitude of this work from meeting such a regiment of engineers. The Commissioners of the Board of Water Supply were all present; also the Commissioner of Water Supply, Gas and Electricity.

Mayor McClellan; Judge Acker, of the State Water Supply Commission; Mr. Sterling, Assistant Corporation Counsel; Mr. Baker, President of the Municipal Civil Service Commission, and President J. Edward Simmons, of the Board of Water Supply, notable among the eminent financiers of the metropolis, each spoke in earnest appreciation of the excellent work that has been going on and gave good counsel for the future, so that every one of these engineers, from rodman to division chief, must have gone back with greater pride in his work and with the encouragement that comes from friendly appreciation.

The mayor's presence was a special mark of appreciation, since it is the only public gathering that he has consented to address this season.

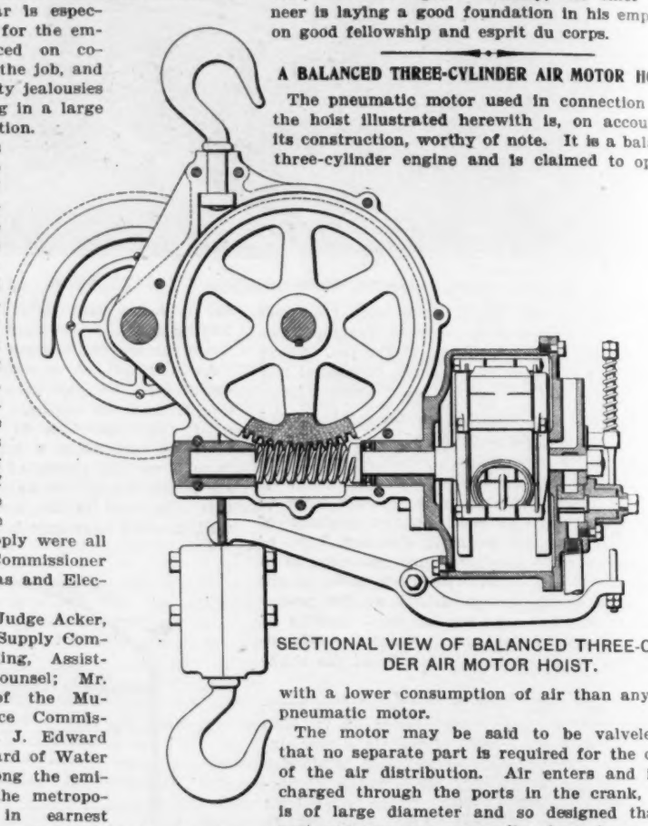
Mr. Smith had invited the engineers in all branches, from roadman to department engineer, foremen of laborers, consulting engineers, and young women office assistants, and in his after-dinner remarks returned thanks for their earnestness, enthusiasm and loyalty to the work. In introducing the mayor, Mr. Smith gave a very interesting story of the mayor's part in forwarding the legislation that led up to the organization of the present work. He spoke with much earnestness of the helpful attitude of the Civil Service Commission and the State Water Supply Commission, and of the constant support of the Board of Estimate.

From the first Mr. Smith has emphasized the value of the cultivation of acquaintance between those on the different divisions of this work. He has called the department engineers together for monthly informal dinners, and arranged to bunch the Saturday half-holidays so that on alternate Saturdays and with alternate field parties, there was first a full Saturday of work and next a full Saturday of holiday, so that visits between departments could be made without interruption of progress.

Throughout the dinner there was all the uproariousness of a lot of college boys off on a lark, and the division cheers and the zest with which songs composed for the occasion were given brought back to the older officials the memories of college days. There were grinds on the delays of the city paymaster, on country boarding houses in winter and even on the consulting engineers, but, with all this, there was a serious undertone and a sentiment of mutual helpfulness which spoke strongly for the vigorous prosecution and success of the work. The Corporation Counsel was heard to remark: "Never before have I seen such a vociferous enthusiasm—and they brought it with them." They are "all right." Plainly, the chief engineer is laying a good foundation in his emphasis on good fellowship and esprit du corps.

A BALANCED THREE-CYLINDER AIR MOTOR HOIST.

The pneumatic motor used in connection with the hoist illustrated herewith is, on account of its construction, worthy of note. It is a balanced three-cylinder engine and is claimed to operate



SECTIONAL VIEW OF BALANCED THREE-CYLINDER AIR MOTOR HOIST.

with a lower consumption of air than any other pneumatic motor.

The motor may be said to be valveless, in that no separate part is required for the control of the air distribution. Air enters and is discharged through the ports in the crank, which is of large diameter and so designed that the port passages are unusually short for a piston motor.

The three radial cylinders are bored from a single steel casting and rotate about the crank. The cylinder bearing about the crank is bushed with a taper bronze sleeve, and wear is taken up simply by driving up on the taper. The thrust of the pistons being outward, and pressure being always exerted between pistons and cylinder head, the cylinders are forced down to a tight seat on the crank, reducing the possibility of leakage. The short ports and passages, taken in connection with the features just mentioned, help toward the economical operation of the motor.

The motor casing is partially filled with oil, which, in running, is thrown over every interior part to be lubricated. As the casing is not under air pressure, there is no tendency to blow or force out the oil. The exhaust air, also, does not enter the casing, so there is no tendency to dry out or carry away the lubricant.

An automatic stop closes the throttle when the load has been lifted to the limit of safety, thus preventing injury to the hoist through the carelessness of the operator. These hoists are built in five sizes with lifting capacities ranging from 1,000 to 10,000 lbs., by the Ingersoll-Rand Co., 11 Broadway, New York City.

We are indebted to them for information concerning the hoist from which the above description has been prepared.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
ATLANTA: Austell Building
RUDOLF MOSSE, BERLIN AND HAMBURG, GERMANY

GEORGE H. FROST, Founder

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The long series of accidents to steel stand-pipes used for water storage has led many engineers to abandon this type of structure and use in its place a tank resting on a high tower.

We illustrate and describe in this issue a reinforced concrete stand-pipe, which may, we believe, bring back the stand-pipe into favor with engineers. The advantages of the concrete stand-pipe over the steel stand-pipe are many, and several of them are enumerated in the article, but there is one particular advantage which we have nowhere seen stated, and which is worth special consideration, and that is the much smaller formation of ice in a concrete stand-pipe. As our readers know, ice in a steel stand-pipe has been a most prolific cause of accidents. In cold climates it is certain to form, and its presence is a constant source of anxiety and danger. In a concrete stand-pipe, however, the water is protected from loss of heat by a wall of concrete 8 to 18 ins. thick instead of by a thin plate of steel. As the heat conductivity of concrete is probably not a twentieth as much as the conductivity of steel, the loss of heat to the air from a concrete stand-pipe of probably 20 times the average thickness of the steel, should be hardly the four hundredth part of the rate of loss from a steel stand-pipe. Of course the actual rate of loss from the steel standpipe is influenced also by the transmission from the water to the metal and from the metal to the air; but as a practical fact we should expect little or no ice to form inside a concrete stand-pipe well covered and with an ample flow of the water in and out. Not only is this of importance on account of the stand-pipe itself, but on account of preserving the water in the stand-pipe from being unduly chilled in regions where deep frosts occur, and frozen mains and service pipes are troubles to be guarded against.

The detailed account of the construction of the Attleboro stand-pipe makes clear that successful structures of this type can be erected; but that their erection demands competent engineering design, intelligent work by the contractor, and first-rate inspection from start to finish. A head of 100 ft. of water is to be treated with due respect, as many builders of steel stand-pipes have found. One batch of concrete in which the cement or the mortar is a little shy, due to oversight of the men at the mixer, may make a lot of trouble when it is put under water pressure. The case is not at all dissimilar to that of a reinforced concrete building, except that even greater vigilance is needed, as every square inch of exposed surface will be tested by searching pressure.

The experience at Attleboro, however, shows that this work can be done and success can be attained. At a cost less than that of a steel stand-pipe, a reinforced concrete stand-pipe can be built which will outlast a dozen steel pipes, which will be far safer from accident, and which may be made an ornament to the landscape instead of an ugly blot.

Announcement is made that a 16-hour train between New York and Chicago is shortly to be placed in service by the Pennsylvania R. R. This announcement comes at a time when other railway companies have taken the radical step of increasing the schedule time of many of their fast trains with tacit acknowledgment that the previous schedules were faster than could be made with a reasonable degree of safety. It comes at a time, too, when the volume of freight traffic pressing upon the railways is greater than has ever before been recorded, and when one prominent railway, the Erie, has cancelled a large number of its suburban passenger trains because the tracks were needed for the movement of freight. At this time, too, public attention is concentrated as never before on the dangers of travel by rail. The epidemic of serious railway disasters which began with that at Atlantic City last fall, still continues. Public confidence in the safety of railway travel and in the efficiency of American railway operating methods, has been seriously shaken. A very material diminution in the amount of pleasure travel by rail is certain to result. Ordinary business prudence as well as every other possible motive, therefore, combine to urge upon railway operating officers the introduction of greater precautions to secure safety.

At this time and under these circumstances, to attempt to operate a 16-hour train between New York and Chicago over the crowded tracks of the Pennsylvania R. R. system, appears to us a most serious mistake. It is puerile to claim that increased speed in railway service does not mean increased risk of accident. Every competent railway officer knows better. We grant that it is perfectly possible to run a passenger train on a clear track in proper condition at speeds of 70 to 80 miles an hour with reasonable safety; but tracks and rolling stock are not always in proper condition. We must allow for a certain percentage of mistakes by employees and imperfections in material. On the New York Central a few days ago a freight train took a side track to get out of the way of a following fast express. The freight should have stopped on the siding, but the rail was icy, the brakes did not hold well, and the freight ran off the end of the siding and onto the main track just ahead of the express train.

We allude to this as but one example at random of the many possible causes of accident which beset the movement of railway trains; and when an accident does occur to a moving train, be it from collision or derailment or other cause, the damage done is pretty certain to be great in proportion to the speed at which the train is moving. To put the case from another point of view, the stored energy in a moving train increases as the square of its speed, so that a train at 70 miles an hour which has to stop to avoid danger ahead will run twice as far after the brakes are applied as it would if the original speed were 50 miles an hour.

Possibly the time may come when 16-hour trains between New York and Chicago may be run with reasonable safety, but it will require large improvements in track, switches, signals, grade crossings and rolling stock, in our opinion to make it possible.

The present campaign against polluted Hudson River ice, instituted by Mr. Edwin Hatch, Jr., Chairman of a committee of the Merchants' Association of New York City, is justly meeting with more public support than has been awarded to Mr. Hatch's fulminations against the pollution of New York Bay.

It is high time to inquire how much longer ice is to be cut, utterly without sanitary control, from the Hudson River below the sewer outlets of Albany, Renssalaer, Troy, Cohoes and other cities with an aggregate population of several hundred thousand. The legislature should lose no time in providing the State Department of Health with full authority to protect both the water and ice supplies of the entire State from pollution. To this end the department must be given control over existing as well as projected sewerage systems, and it must also have more definite control of both water and ice supplies.

But mere statutory authority will be of little use unless the department is provided with money to make the studies of water pollution essential to the formulation of orders that will stand the test of the courts. We need not enlarge upon this point at present. Instead, we will raise the question whether it would not be for the interest of the ice company to abandon its questionable Hudson River ice source before it is compelled to do so—that is, yield to the demands of public opinion and public sanitation rather than await the action of the law. Lake Champlain would afford a comparatively unquestionable supply of unlimited volume, at only a slight additional cost for transportation. Of course, new ice houses would be required, but doubtless the company would find a way of making up for the extra cost on this account. As everybody knows, the ice trust already has the distrust of the public. If in addition to its recent manipulation of its supply and prices to fill its treasury it gets the discredit of providing its customers with frozen sewage it need not be surprised if it soon has to fight a plan for a municipal ice supply.

American engineers have been cautious about recommending moving sprinklers for sewage filters of the percolating type lest the sprinklers be rendered inoperative in severe winter weather. The unusually cold winter in England this year has given rise to trouble at two towns in Gloucestershire (in the south of England). Tank effluent is applied to filter beds by rotary sprinklers in each case; at one place the sprinklers are perforated pipes and at the other they are "open arms"—evidently overflowing pipes. Recent experience with these filters is described in a letter dated Jan. 29, 1907, published in the Local Government Official (London), as follows:

> These filters have been rendered entirely inoperative during the recent frost, not only because the rotating arms have been firmly anchored to the bed by icicles, but, and more seriously, because the gear by which the liquid is periodically discharged with the force necessary to move the sprinkler is immovably fixed in the position of discharge, and until a solid mass of ice weighing 1 cwt. is melted, it is plainly impossible for the plant to resume operations. Meantime of course the liquid is taking its own course through the bed immediately under the arms, and is not spread over the surface. This seems to me to be a serious defect, and, as after a series of exceptionally mild winters we may reasonably anticipate colder ones, one that is likely to recur.

It will be noted that the automatic dosing gears, as well as the revolving sprinklers, have been put out of commission at these sewage works. It would seem to be a simple matter to protect dosing gears against frost, but obviously it would be impracticable to so protect rotary sprinklers, since that could not be done short of housing the whole filter area. It would be interesting to know the experience with rotary sprinklers and exposed dosing gears in the north of England and in Scotland during the recent severe weather there.

Little has appeared in print on the subject of designing reinforced concrete for maximum economy. Analysis and discussion have dealt only with design for strength, basing on stresses that correspond to equal and complete utilization of both the concrete and the steel. Now, the fact is that many times a cheaper design results when one of the two materials is less fully utilized. This is mathematically proven in an article which appears on another page of this issue. The author, Mr. F. W. Hanna, computes tables of the stress-ratio which secures maximum economy under different sets of specified conditions. He shows, for example, that under certain conditions of relative cost of steel and concrete the most economical design employs

relative stresses of 30 to 1, under other conditions 40 to 1, and so on; the percentage of reinforcement, of course, is in each instance fixed by the stress ratio. It is worth special note that according to these results much lower percentages of reinforcement than are commonly used should prove more economical.

Be it noted that the analysis and deduced computations made by Mr. Hanna deal only with a single general case, and that other cases, more complex ones as well as more elementary ones, remain to be studied. Thus, take the case of a flat roof of reinforced concrete, and suppose that the span is as large as 30 ft. Now, the live-load to be provided for is rarely outside of the limits 30 to 50 lbs. per sq. ft. The dead-load (including girders) may on the contrary run up to 100 lbs. per sq. ft., so that the total load is to a large extent dependent on the design. Evidently it will be desirable to design as light a roof as possible, provided the very light roof is not very much more costly than the heavier one. In Mr. Hanna's analysis, the beam is to be designed for a fixed (constant) moment, and it is shown that under certain conditions the cheapest beam is secured by one-half of one per cent. reinforcement. But this is a much heavier beam than one that has three times as much reinforcement. The question then is: Can the beam of greater steel percentage, designed for a smaller total load, be built cheaper than the 0.5% beam which must carry a greater load? The question is rather refractory under mathematical treatment.

But even the specific problem which Mr. Hanna studies is often, perhaps generally, affected by complicating factors which he has not included, at least two and perhaps three: First, the amount of metal required in the form of stirrups, etc.; this is tacitly assumed to be constant, in Mr. Hanna's calculation, although it might perhaps more correctly be taken as proportional to the sectional area of main reinforcement. Second, the lesser cost of *additional* steel as against the cost of the initial steel; in a beam containing 400 lbs. of metal, as compared with one containing 300 lbs., the added cost of the 100 lbs. of steel, *in place*, is probably not much more than the f. o. b. cost of 100 lbs., or in other words this 100 lbs. costs virtually nothing to bend, assemble and place. Third, the increase in cost of forms as the depth of beam is increased or as the weight of beam is decreased (reinforcement percentage decreased). The theoretical difficulties of taking these factors into account are great. But the greater difficulty, perhaps, is the practical one that the values of the constants are hard to fix, and at best are probably not definite. What reinforced-concrete contractor, for example, is able to state the cost of assembling, and placing the steel, or the added cost of stirrups due to the greater difficulty of placing the concrete?

CLOSING THE BREAK IN THE COLORADO RIVER BANKS.

We trust the engineering profession appreciates, even though the general public may not, the magnitude of the victory which has just been won in the far Southwest in restoring the Colorado River to its old channel. The events of the battle, which has been waged for nearly two years now, have been recorded from time to time in these columns, and in our issue of Dec. 27 last, the commanding general of the army which was contending with the turbulent flood, himself told the story of the successive defeats which have eventually paved the way to final success. We need not repeat that story here; but some comment on and discussion of this unprecedented piece of engineering work seems appropriate at this time.

To briefly recapitulate, first, for the benefit of those of our readers who may not have followed our articles already published: For more than two years now a large part of the flow of the Colorado River has been diverted from its normal course into the Gulf of California, and has been passing into the great sink or depression below sea level, lying to the westward of Yuma, Ariz. This diversion was caused by the cutting of an irrigation canal intake *without head gates*, on Mexican territory, in October, 1904. The depression into which this stream has been flowing is the old delta of the Colorado River, and is composed of light, easily moved soil of unknown depth. In flowing from the break in the banks to the Salton Sea, at the lowest point in the sink, the river has had a fall of over 200 ft. in a distance of about 100 miles. The result was rapid erosion of the channel and the formation of cascades and rapids at the points of steepest slope, which have been rapidly cutting their way back toward the point where the original break in the river occurred.

Had the break not been closed this winter, before the spring floods came down the Colorado, this deep gulch would have been carried clear back to the main Colorado, and would have rendered it impossible by any puny agency of man's contrivance to turn the river again to its old course direct to the Gulf.

As shown by President Roosevelt, in our issue of Jan. 17, this event would have been a calamity almost without a parallel in history, not indeed because of present property damage, although that would reach many millions, but because it would render forever impossible the reclamation of a vast tract of fertile land, a veritable future empire of prosperous agriculture.

By centuries of labor and vast expense, the Dutch nation has reclaimed the land it inhabits from the bottom of the sea; but this great tract in the Southwest has been reclaimed from the sea by Nature's own efforts. It only awaits the proper application of the water now flowing past it to become a far more fertile and productive region than the fields that Holland's dikes protect. It would have been a crime against civilization had this great tract of land been lost to mankind and suffered again to become a waste of waters, instead of being improved with the farms and homes of a prosperous people.

We have said above that the general public little realizes the importance of this battle that has been fought and won in the torrid deserts of the Southwest. There is a popular notion that the flooding of the Salton Sink and the loss of this great tract of irrigable land, might be compensated for by an increased rainfall in the Southwest, due to the evaporation from the Salton Sea. That there is a remote possibility of such an effect cannot be denied; but the facts all indicate that such a change in climate is in the highest degree unlikely. To fill Salton Sea with the Colorado's flow would merely amount to moving the head of the Gulf of California 150 miles farther northward. The peninsula of Lower California, bordered on one side by the Pacific and on the other by the Gulf of California, is one of the most arid regions known. The enormous evaporation from the great bodies of water close beside it has no effect on its rainfall. The same thing is true of the Mexican territory on the mainland. Why then should a small extension of the Gulf northward be expected to have any material influence in increasing the rainfall on adjacent lands? If more evidence is desired, one might point to the arid countries adjoining the Mediterranean and Red Seas, where evaporation is enormous and yet rainfall is almost non-existent.

We have alluded to this matter here only to correct a popular misconception that there might be some compensating benefit if the Colorado River were allowed to fill the Salton Sink. No fallacy of that sort in the public mind ought to diminish the importance of the victory won.

And now let us ask whether the victory is really won. That the flow to the Salton Sea is stopped we know; but can the fortifications which have been thrown up against the river be held against the attacks of the vast floods which go down the valley in May and June, reaching frequently a hundred thousand cubic feet per second? As our readers know, the breach was closed once before, last November; but the levee built below the closure works was broken by the floods which came down in December.

It may be thought strange that the river which has for centuries, doubtless, flowed direct to the sea, should now have so strong a tendency to turn toward the Salton Sea. If the break were once closed, why should the river break through the levees above or below?

The probable explanation of this, we believe, is that there has been an actual raising of the bed of the old channel of the river during the two years while the crevasse has been open. During this time the old bed of the river, leading to the Gulf has part of the time been entirely dry, and when water has flowed in it, it has been at flood times when it was heavily burdened with sediment. The dropping of this sediment below a crevasse, due to the lessened velocity from the loss of part of the waters, is a familiar phenomenon to those engaged in river regulation engineering.

Whatever may be the cause for this greater tendency of the Colorado's waters to stray from their old course, it is clear now that they must be restrained at any cost. If necessary, a substantial levee should be constructed all the way from the present closure works to the Gulf. The risk of another crevasse, natural instead of artificial, must be eliminated. It is probable that if the whole flood flow of the Colorado is once restored to its old channel, any shoaling of its bed that may have taken place since the crevasse will be removed and the former regimen of the stream will be restored.

The necessity for holding the Colorado in its old channel with absolute certainty has now been shown by a great object-lesson. It is apparent that this necessity will increase from now on with the rapid influx of settlers to the Imperial Valley. Every farm and home there is dependent on the strength of the banks by which the river is held in check, just as surely as every house and hamlet in the Holland polders is independent on the strength of the dikes. Now that the river is restored to its old channel, there should be no engineering difficulty in holding it there with certainty, and in giving perfect safety to those in the valley below.

We have said there is no engineering difficulty. There are other difficulties, however, of a most serious sort. The work of closing the break has been done by the Southern Pacific Co. That railway corporation responded most nobly to the appeal of President Roosevelt. It was absolutely the only organization that was able to do the work in time, and time, as shown above, was the all-important element. Unless the closure was effected at once, it could not be effected at all. No other organization, great or small, not even the United States Government itself, had the Executive been given unlimited powers by Congress, could possibly have brought together the men and tools and materials in time to save the day.

But now that the emergency has been met and there is time to look to the future, the railway company which has so honorably met the call of public duty ought to be relieved of further responsibilities. When the question is asked where the responsibility should now be placed for the permanent control of the Colorado River, it is difficult to find any other reasonable course than for the United States to take charge. That no private irrigation company, organized for business and profit, could well be trusted with such great responsibility, should be clear anyway, and has certainly been demonstrated with absolute conclusiveness by the events of the past three years in this region.

It may be suggested that the States could assume control; but part of the land to be protected lies in California, part in Arizona, and a considerable part, including the whole lower course of the Colorado where breaks must be guarded against, is in the Republic of Mexico. Thus the protection of a large area of United States territory from inundation depends on the control of a river channel in Mexico.

We can see no satisfactory solution of this difficult problem except the purchase from Mexico of this territory and its annexation to the United States. At present this country is in the anomalous position of having a great valley of enormous potential value which is likely at any time

to be flooded and destroyed for all time by a river on foreign territory overflowing its banks. Mexico on the other hand, has either to control the river herself, to protect her neighbor, or admit foreign forces to her soil to do the work.

The whole situation is so likely to lead to international complications that there should be no difficulty in arranging a satisfactory treaty of annexation. Conceivably, Mexico may desire to retain a narrow strip at the very mouth of the Colorado to give her access by land to her territory in Lower California; but this might possibly be met by purchasing the whole lower peninsula. While this has little value, save possibly for mineral deposits, yet unknown, its possession would place under United States jurisdiction a region commonly reputed to be a resort for fugitives from justice.

A word should be said regarding the unprecedented methods adopted to close the crevasse. The problem was one never before presented, so far as we are aware, in all the annals of engineering. Here is a great river subject to extreme and sudden variations of flow, from 2,000 to 100,000 cu. ft. per second. Its whole volume is flowing through a crevasse in its banks some 2,000 ft. in width, and the whole region is one mass of silt and mud, no solid foundation anywhere. Worst of all, the time to effect closure is extremely limited. There is no time to make elaborate plans, and little time even to consult as to what is to be done.

Under such circumstances it would be ungracious to criticize what was done or not done. It appears to be clear that the early attempts at closure, described in our issue of Dec. 27, were a failure largely because the magnitude of the task in hand was not appreciated, and also because the funds and forces available were inadequate for the work. Of the later efforts, when the whole strength of the Southern Pacific organization was concentrated on this work, the plan of work in which the wooden gate was constructed appeals to an engineer as sound and well schemed. The plan would undoubtedly have been carried to success had not the drift carried down by the flood lodged against the gate and obstructed the passage of water through it.

The method by which successful closure of the breach was finally effected consisted, as already recorded, of carrying pile trestles across the crevasse and dumping rock as rapidly as possible from these trestles, thus making a rock-fill dam across the channel. Had any considerable height been attempted with these dams, the scour would doubtless have concentrated at some point and undermined the trestle; but by making successive lines of parallel trestles and dams, the fall at each was kept within moderate limits and the structure remained in place.

This simple plan of operation, while it presented many possibilities of failure, offered the very great advantage of doing the work with railroad machinery and railroad methods, and therefore of rapidly effecting results. We can conceive of no other method by which an effective barrier could have been constructed across the crevasse in the limited time available. It will be apparent also, that had it not been for the branch line built last summer to the site of the break from the main line of the Southern Pacific Co., it would have been impossible to have assembled the men, material and supplies necessary to effect the closure of the break by this or any other method of operation.

In discussing this subject a month ago, when the possibility of closing the breach was still a matter of grave doubt, we said that Congress ought to act immediately on the President's appeal for funds. Now that the Southern Pacific Co. has gone forward and completed successfully the task, relying on the honor of the Nation to reimburse it for its expenditure, we say with renewed emphasis that Congress ought to act promptly and justly in this matter. Doubtless corporations have no souls, and this particular one has been frequently accused of lacking all moral principle in addition. In the present case, however, it has shown something of the same honorable quality that impels a man to risk his own life or property to check a conflagration when no one else is at hand to act. The Southern Pacific Co. is entitled to fair and liberal recompense at the hands of the Nation for the great service it has performed, and it would be a proper thing also to recognize in some appropriate way the efficient services of the leaders in the field who have finally won a great victory after the discouragement of repeated defeats.

LETTERS TO THE EDITOR.

Electric Railways With Steep Grades in Seattle.

Sir: In your issue of Jan. 24 you mention "A counterweight device for operating an electric railway * * * on a grade steeper than the 10% which is generally accepted as the maximum allowable with ordinary methods * * *."

Electric railways are being operated in Seattle on grades up to 16.2% by ordinary methods. The two steepest are 15.9% and 16.2%. Railways operated over grades of from 10 to 13% are nearly as common as grades of 5% in most cities.

The first counterbalance system in the world was put in operation in Seattle about 16 years ago. It is still in operation, and accidents of more than a minor nature have never occurred on it.

The grade of 16.2% was originally operated with counterbalance, but accidents have been less frequent since ordinary methods were adopted. Each car has a track brake and hand brake.

Yours truly,

Walter S. Wheeler.

Seattle, Wash., Jan. 31, 1907.

How Far is the Water-Works Engineer Responsible for Typhoid Fever Epidemics?

Sir: In discussing the above-named subject in your issue of January 31, "Inquirer" is unfortunate in illustrations. Bridge engineers hardly insist upon weaknesses that the past has shown to be dangerous. Structural engineers do not subject their buildings to many times the calculated load unless through ignorance or by some accident. A fairer illustration might have been found in an engineer for a railway company whose roadbed and equipment were not quite up to the standard of a trunk line. He might say "accidents will be certain to occur upon this road because they do occur on trunk lines that have 95-pound rails and the most modern equipment." It would be his privilege to resign or to try to bring his road up to a better standard, remembering that the trunk lines were not always as perfect as they are to-day.

There was little need, however, for "Inquirer" to go outside of the department of work which he had under discussion. Suppose an engineer thought the water supply under his care was subject to pollution and took up the matter with the proper authorities, finally reaching the State Board of Health, who caused examination to be made, and reported that while there were evidences of pollution the sources of pollution were so far away that there was no danger. Suppose the engineer still thought, foolishly perhaps, that there was danger, should he then give up his position, perhaps to one not so particular as himself?

Suppose in a water-works case similar to the one described by "Inquirer" the fact became clearly established that pollution originated upon the right-of-way and from the trains of a railroad located upon the drainage area. What course would he advise, or what should have been advised, previous to the breaking out of typhoid fever and a general discussion of the whole subject?

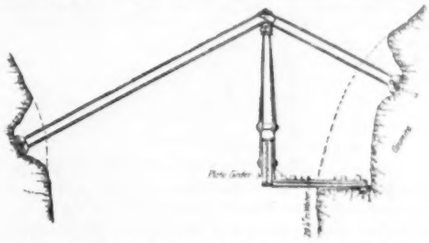
The chief engineer for a municipal or company works can send his assistants to examine fixtures in the residence of a consumer, but this is a matter of agreement. Such right to inspect would not extend to the premises of a resident who owned the banks of a brook tributary to a water supply and who might ignorantly affirm that all house drainage was properly taken care of by cesspools, when as a matter of fact it was discharged as raw sewage into the stream. A city council is authorized by the Legislature of the State to exercise conduct-regulating or police power, but it cannot well transfer this authority to a company. This fact is generally recognized in water-works franchises under a section which is intended to make it compulsory upon the municipality to pass ordinances protecting sources of supply and the property of the water company. When these ordinances are passed they should be enforced. Let it be supposed for a moment that the quality of a supply depended upon such enforcement. Would it be the duty of a municipal or company engineer to insist upon their enforcement or tender his resignation?

These are fairly typical cases and questions about which one might exercise his good judgment to better purpose than in the illustrations cited by your correspondent. "Engineer."

New York, Feb. 13, 1907.

The Designer of the "Hanging Bridge" Over the "Royal Gorge."

Sir: Let us correct a little history before it is everlastingly too late. Some time ago, in reporting the death of Mr. J. R. Dereemer, who was for several years an engineer connected with the Denver & Rio Grande R. R., the public press insisted on giving him the credit for designing and constructing the famous "Hanging Bridge" located in the still more famous "Royal Gorge," and the same information got into your journal. Now, in your issue of Jan. 10, I notice that in the report of the death of Colonel Charles H. Irvin, he is credited with the same work. I was well acquainted with both of these gentlemen, and I think there was no question as to their



"Hanging Bridge" in the Royal Gorge, Colorado, Denver & Rio Grande R. R.

ability as engineers; but as a matter of fact, what is now the Denver & Rio Grande R. R., from Canon City to Leadville, Colo., was nearly all graded by the Atchison, Topeka & Santa Fe Ry. and the track was also laid by it for a distance of about 22 miles, and included the building of the "Hanging Bridge." I was connected with the latter company at that time, and if I am rightly informed the credit for the design of the "Hanging Bridge" should be given to Mr. A. A. Robinson, at that time Chief Engineer of that company. I remember that a young gentleman from St. Louis, Mo., by name of Taussig had charge of the work for the bridge company.

I suppose I should explain, that during the time that this construction work was being done, there was a legal battle going on almost continuously between the two companies, and that it was finally decided in favor of the Denver & Rio Grande R. R.

It is not my desire to detract from the laurels of either of these gentlemen, but it is my desire that the credit, if credit there be, should go to whom it belongs.

Yours truly, P. F. Barr.

Room 5, Boston Bldg., Denver, Colo., Jan. 16, 1907.

[The bridge in question was briefly described in a paper on "Bridging Canyons Lengthwise" by Mr. H. V. Hinckley, printed in the Transactions of the American Society of Civil Engineers, Vol. XXVI., p. 521. This paper was abstracted in Engineering News, June 30, 1892, and we here reproduce a cut used in that issue, which shows the general manner of supporting the bridge. It is probably well known, however, that the structure is no longer a "hanging bridge," the girders being now supported from below by a wall built up from the bed of the canyon. In the paper referred to above, the author makes no specific mention as to the designer of the bridge, but mentions that it was built under the direction of Mr. Robinson. In order to clear the matter up we sent a proof of Mr. Barr's letter to Mr. Robinson, who replied as follows:—Ed.]

Sir: In reply to your letter of the 22d inst., Mr. Barr states the case correctly as to the Royal Gorge hanging bridge.

I was Chief Engineer of this construction. It is due, however, to the late C. Shaler Smith (at that time a civil engineer of note residing in St. Louis, Mo.) to say that we visited the bridge site together and decided on the rafter plan of construction.

It was impracticable to take contours for study and I preferred to have Mr. Smith on the ground with me as above.

I engaged Mr. Smith to prepare the detail plans from which the original bridge was constructed.

Yours very truly,

A. A. Robinson.

900 Tyler St., Topeka, Kan., Jan. 25, 1907.

Tables for Proportioning Beams.

Sir: I have found tables such as given herewith very convenient for rapidly determining the sizes of beams. Two tables are required: First, Table A giving the value of I/c required to resist a given load on a given span, and second, Table B giving the values of I/c for different sections. For general use Table B should include rectangular sections, I-beams, channels, angles and other sections that are used often. But the table herewith

covers only simple rectangular sections, in sizes from 4 × 4 ins. to 16 × 24 ins. The following explains the make-up and use of the tables:

The theory of flexure informs us that in any beam of homogeneous material the sum of all the moments of the internal horizontal stress in any section about any axis parallel to the neutral axis is equal to S I/c, where S is the horizontal unit stress (tensile or compressive) in the fiber most remote from the axis, c is the distance of this fiber from the neutral axis, and I is the moment of inertia of the section about the neutral axis. Then, if M be the external bending moment, we must have

$$M = \frac{S\,I}{c}.$$

By substituting in this equation the dimensions and quantities for any given beam we derive formulas for the special cases.

Assume the following:

P = load in the middle of the beam;
W = total load distributed uniformly;
l = total length of the beam, in inches;
b = breadth, in inches;
d = depth, in inches.
S = stress in extreme fiber, in lbs. per sq. in.

Substituting these values for different conditions of loading there result the general formulas:

Beam fixed at one end loaded at the other	$P = Sbd^2/6l$
Beam fixed at one end loaded uniformly	$W = Sbd^2/3l$
Beam supported at ends loaded in the middle	$P = 2Sbd^2/3l$
Beam supported at the ends loaded uniformly	$W = 4Sbd^2/3l$
Beam supported at ends loaded uniformly and loaded in the middle	$2P + W = 4Sbd^2/3l$
Beam fixed at both ends loaded in the middle	$P = 4Sbd^2/3l$
Beam fixed at both ends and loaded uniformly	$W = 2Sbd^2/l$

In order to make clear the method of solving these formulas by using the table given we will first take the formula for a beam supported at the ends and loaded uniformly. This may be changed to read

$$W/S = 4bd^2/3l.$$

In Table A the vertical column at the left, reading 1, 2, 3, 4, etc., gives the value of W/S. The horizontal column at the top, reading 10, 11, 12, 14, etc., gives the length of beam in feet. In the body of the table we find the value $bd^2/6$, which is equal to I/c for a rectangular section. The combination of b and d which will give this value may be found from Table B.

Since the strengths of beams are proportional to the I/c of corresponding sections, the value taken from the table for $bd^2/6$ may be equated to the I/c of a beam of any section. This makes Table A handy in the design of steel work.

The formulas above given for other conditions of support and loading may be put in a form that will permit the use of Table A. The procedure then is as follows: In every case divide the total load W or P by the desired unit stress. Determine from Table A the value I/c or $bd^2/6$ as though the beam in question were simply supported at the ends and loaded uniformly. Then multiply the value so found by a constant factor, given in the following list:

Beam fixed at one end and loaded at the other	$bd^2/6$ = Tabular Value × 8
Beam fixed at one end and loaded uniformly	$bd^2/6$ = Tabular Value × 4
Beam supported at ends and loaded in the middle	$bd^2/6$ = Tabular Value × 2
Beam supported at ends and loaded uniformly	$bd^2/6$ = Tabular Value × 2
Beam supported at ends and loaded in middle and with uniform load (for total load use 2P + W)	$bd^2/6$ = Tabular Value × 2
Beam fixed at ends and loaded in the middle	$bd^2/6$ = Tabular Value × 2
Beam fixed at ends and loaded uniformly	$bd^2/6$ = Tabular Value × 2/3

As an example for illustration suppose it is desired to determine the cross-section of a rectangular wooden beam 24 ft. in length fixed at one end and loaded uniformly, where W = 5,000, S = 1,000.

$$\frac{W}{S}\frac{5{,}000}{1{,}000} = 5;$$

$$\frac{I}{c}\ \text{Tabular Value} = 180;$$

$$\text{Multiplier} = 4;\ \text{hence}\ \frac{I}{c} = 4 \times 180 = 720.$$

From Table B, the width and depth (b and d) may be 14 × 18, 15 × 17 ins., etc.

When a steel I-beam is to be used for the same purpose, unit stress 16,000:

$$\frac{5{,}000}{16{,}000} = \frac{5}{16}$$

$$4 \times \frac{5}{16} = 1.25.$$

From Table A, $\frac{I}{c} = 45.$

A 15-in., 42-lb. I-beam has a moment of inertia of 441.8.

Yours truly, G. L. Bilderbeck.

East Berlin, Conn., Feb. 8, 1907.

TABLE A.—VALUES OF REQUIRED I/c FOR SIMPLE BEAMS.

Given: Load W (uniform), in pounds, Unit Stress in extreme fiber, S, in pounds per square inch; Span of Beam, l, in feet.

W/S	Span l, in feet.— 10 ft.	11 ft.	12 ft.	14 ft.	16 ft.	18 ft.	20 ft.	22 ft.	24 ft.	26 ft.	28 ft.	30 ft.	32 ft.	36 ft.	40 ft.
1	15	16.5	18	21	24	27	30	33	36	39	42	45	48	54	60
2	30	33.0	36	42	48	54	60	66	72	78	84	90	96	108	120
3	45	49.5	54	63	72	81	90	99	108	117	126	135	144	162	180
4	60	66.0	72	84	96	108	120	132	144	156	168	180	192	216	240
5	75	82.5	90	105	120	135	150	165	180	195	210	225	240	270	300
6	90	99.0	108	126	144	162	180	198	216	234	252	270	288	324	360
7	105	115.5	126	147	168	189	210	231	252	273	294	315	336	378	420
8	120	132.0	144	168	192	216	240	264	288	312	336	360	384	432	480
9	135	148.5	162	189	216	243	270	297	324	351	378	405	432	486	540
10	150	165.0	180	210	240	270	300	330	360	390	420	450	480	540	600
11	165	181.5	198	231	264	297	330	363	396	429	462	495	528	594	660
12	180	198.0	216	252	288	324	360	396	432	468	504	540	576	648	720
13	195	214.5	234	273	312	351	390	429	468	507	546	585	624	702	780
14	210	231.0	252	294	336	378	420	462	504	546	588	630	672	756	840
15	225	247.5	270	315	360	405	450	495	540	585	630	675	720	810	900
16	240	264.0	288	336	384	432	480	528	576	624	672	720	768	864	960
17	255	280.5	306	357	408	459	510	561	612	663	714	765	816	918	1,020
18	270	297.0	324	378	432	486	540	594	648	702	756	810	864	972	1,080
19	285	313.5	342	399	456	513	570	627	684	741	798	855	912	1,026	1,140
20	300	330.0	360	420	480	540	600	660	720	780	840	900	960	1,080	1,200
21	315	346.5	378	441	504	567	630	693	756	819	882	945	1,008	1,134	1,260
22	330	363.0	396	462	528	594	660	726	792	858	924	990	1,056	1,188	1,320
23	345	379.5	414	483	552	621	690	759	828	897	966	1,035	1,104	1,242	1,380
24	360	396.0	432	504	576	648	720	792	864	936	1,008	1,080	1,152	1,296	1,440
25	375	412.5	450	525	600	675	750	825	900	975	1,050	1,125	1,200	1,350	1,500
26	390	429.0	468	546	624	702	780	858	936	1,014	1,092	1,170	1,248	1,404	1,560
27	405	445.5	486	567	648	729	810	891	972	1,053	1,134	1,215	1,296	1,458	1,620
28	420	462.0	504	588	672	756	840	924	1,008	1,092	1,176	1,260	1,344	1,512	1,680
29	435	478.5	522	609	696	783	870	957	1,044	1,131	1,218	1,305	1,392	1,566	1,740
30	450	495.0	540	630	720	810	900	990	1,080	1,170	1,260	1,350	1,440	1,620	1,800
31	465	511.5	558	651	744	837	930	1,023	1,116	1,209	1,302	1,395	1,488	1,674	1,860
32	480	528.0	576	672	768	864	960	1,056	1,152	1,248	1,344	1,440	1,536	1,728	1,920
33	495	544.5	594	693	792	891	990	1,089	1,188	1,287	1,386	1,485	1,584	1,782	1,980
34	510	561.0	612	714	816	918	1,020	1,122	1,224	1,326	1,428	1,530	1,632	1,836	2,040
35	525	577.5	630	735	840	945	1,050	1,155	1,260	1,365	1,470	1,575	1,680	1,890	2,100
36	540	594.0	648	756	864	972	1,080	1,188	1,296	1,404	1,512	1,620	1,728	1,944	2,160
37	555	610.5	666	777	888	999	1,110	1,221	1,332	1,443	1,554	1,665	1,776	1,998	2,220
38	570	627.0	684	798	912	1,026	1,140	1,254	1,368	1,482	1,596	1,710	1,824	2,052	2,280
39	585	643.5	702	819	936	1,053	1,170	1,287	1,404	1,521	1,638	1,755	1,872	2,106	2,340
40	600	660.0	720	840	960	1,080	1,200	1,320	1,440	1,560	1,680	1,800	1,920	2,160	2,400
41	615	676.5	738	861	984	1,107	1,230	1,353	1,476	1,599	1,722	1,845	1,968	2,214	2,460
42	630	693.0	756	882	1,008	1,134	1,260	1,386	1,512	1,638	1,764	1,890	2,016	2,268	2,520
43	645	709.5	774	903	1,032	1,161	1,290	1,419	1,548	1,677	1,806	1,935	2,064	2,322	2,580
44	660	726.0	792	924	1,056	1,188	1,320	1,452	1,584	1,716	1,848	1,980	2,112	2,376	2,640
45	675	742.5	810	945	1,080	1,215	1,350	1,485	1,620	1,755	1,890	2,025	2,160	2,430	2,700
46	690	759.0	828	966	1,104	1,242	1,380	1,518	1,656	1,794	1,932	2,070	2,208	2,484	2,760
47	705	775.5	846	987	1,126	1,269	1,410	1,551	1,692	1,833	1,974	2,115	2,256	2,538	2,820
INTERPOLATION.															
1	1.5	1.65	1.8	2.1	2.4	2.7	3.0	3.3	3.6	3.9	4.2	4.5	4.8	5.4	6.0
2	3.0	3.30	3.6	4.2	4.8	5.4	6.0	6.6	7.2	7.8	8.4	9.0	9.6	10.8	12.0
3	4.5	4.95	5.4	6.3	7.2	8.1	9.0	9.9	10.8	11.7	12.6	13.5	14.4	16.2	18.0
4	6.0	6.60	7.2	8.4	9.6	10.8	12.0	13.2	14.4	15.6	16.8	18.0	19.2	21.6	24.0
5	7.5	8.25	9.0	10.5	12.0	13.5	15.0	16.5	18.0	19.5	21.0	22.5	24.0	27.0	30.0
6	9.0	9.90	10.8	12.6	14.4	16.2	18.0	19.8	21.6	23.4	25.2	27.0	28.8	32.4	36.0
7	10.5	11.55	12.6	14.7	16.8	18.9	21.0	23.1	25.2	27.3	29.4	31.5	33.6	37.8	42.0
8	12.0	13.20	14.4	16.8	19.2	21.6	24.0	26.4	28.8	31.2	33.6	36.0	38.4	43.2	48.0
9	13.5	14.85	16.2	18.9	21.6	24.3	27.0	29.7	32.4	35.1	37.8	40.5	43.2	48.6	54.0
10	15.0	16.50	18.0	21.0	24.0	27.0	30.0	33.0	36.0	39.0	42.0	45.0	48.0	54.0	60.0

NOTE.—Scales of span and W/S are interchangeable.

TABLE B.—VALUES OF bd ²/6 FOR RECTANGULAR SECTIONS.

NOTE—c & l. c., under table heading, like "span l, in feet" in Table A.

Depth, ins.	4 ins.	5 ins.	6 ins.	7 ins.	8 ins.	9 ins.	10 ins.	11 ins.	12 ins.	13 ins.	14 ins.	15 ins.	16 ins.
4	10.7	13.3	16.0	18.7	21.3	24.0	26.7	29.3	32.1	34.7	37.3	40.0	42.7
5	16.7	20.8	25.0	29.2	33.3	37.5	41.7	45.8	50.0	54.2	58.3	62.5	66.7
6	24.0	30.0	36.0	42.0	48.0	54.0	60.0	66.0	72.0	78.0	84.0	90.0	96.0
7	32.7	40.8	49.0	57.2	65.0	73.5	81.7	89.8	98.0	106.2	114.3	122.5	130.0
8	42.7	53.3	64.0	74.7	85.3	96.0	106.7	117.0	128.0	138.7	149.0	160.0	171.0
9	54.0	67.5	81.0	94.5	108.0	121.0	135.0	150.0	162.0	175.5	189.0	202.0	216.0
10	66.6	83.3	100.0	116.7	133.0	150.0	167.0	183.0	200.0	216.0	233.0	250.0	266.0
11	80.6	100.8	121.0	141.0	161.0	182.0	202.0	222.0	242.0	262.0	282.0	302.0	323.0
12	96.6	120.0	144.0	168.0	192.0	216.0	240.0	264.0	288.0	312.0	336.0	360.0	384.0
13	113.0	141.0	169.0	197.0	225.0	253.0	282.0	310.0	338.0	366.0	394.0	422.0	451.0
14	131.0	163.0	196.0	229.0	261.0	294.0	327.0	359.0	392.0	425.0	457.0	490.0	522.0
15	150.0	187.0	225.0	263.0	300.0	338.0	375.0	412.0	450.0	487.0	525.0	563.0	600.0
16	170.0	213.0	256.0	299.0	341.0	384.0	427.0	469.0	512.0	555.0	597.0	640.0	683.0
17	193.0	241.0	289.0	337.0	385.0	433.0	482.0	530.0	578.0	626.0	674.0	723.0	771.0
18	216.0	270.0	324.0	378.0	432.0	486.0	540.0	594.0	648.0	702.0	756.0	810.0	864.0
19	241.0	301.0	361.0	421.0	481.0	542.0	602.0	662.0	722.0	782.0	842.0	903.0	963.0
20	267.0	333.0	400.0	467.0	533.0	600.0	667.0	733.0	800.0	867.0	933.0	1,000.0	1,067.0
21	294.0	367.0	441.0	515.0	588.0	661.0	735.0	805.0	882.0	955.0	1,029.0	1,102.0	1,176.0
22	323.0	403.0	484.0	565.0	645.0	726.0	807.0	887.0	968.0	1,049.0	1,129.0	1,210.0	1,291.0
23	353.0	441.0	529.0	617.0	705.0	794.0	882.0	970.0	1,058.0	1,146.0	1,234.0	1,323.0	1,411.0
24	384.0	480.0	576.0	672.0	768.0	864.0	960.0	1,056.0	1,152.0	1,248.0	1,344.0	1,440.0	1,536.0

Concerning the Definition of an Engineer.

Sir: In view of the recent experience of the Committee on the Constitution of the American Society of Civil Engineers, finding it impossible to reconcile the differences of opinion regarding a definition for the words "engineer" and "engineering," it is perhaps futile to suggest a fresh definition. The writer has, however, derived considerable amusement, and he hopes some mental profit, for some years past in formulating definitions of more or less nebulous concepts, including the much misused terms in question. His first quarrel was with the practice (which he considers atrocious in the extreme) of calling all surveyors, when called into court to testify as to maps and distances, "engineers."

To one who has some accurate knowledge of definitions, as most lawyers undoubtedly have, this practice must smack strongly of childishness and vanity. One who is called as an (expert or not) "Engineer" to give testimony as to the operation of natural forces or laws may properly be called by that title. One who is called to identify a map or profile and swear to the accuracy and completeness of the survey represented thereby is properly a surveyor and should take a just pride in that title.

In our eastern courts, at least, and probably west as well, most damage suits and many criminal suits are partly, at least, based on such a map and the surveyor is put upon the stand to identify and explain it. The writer has been subjected to the process several times and speaks from no academic standpoint. It is no answer that the witness is actually an engineer. He may also be a photographer, a master of arts, a naval architect, or a machinist. He is called to the stand to give evidence as Surveyor, and should insist on that title and none other. He would thereby gain the respect and approval of all accurate thinkers, at least, and the writer, for one, values their good opinion higher than that of almost any other class of men. The writer, therefore, holds that a definition of the term engineer should exclude the surveyor per se. Of course one can be a surveyor and an engineer as well; so can he be a chemist, or a miscroscopist, or an astronomer.

The present (January, 1907) Constitution of the American Society of Civil Engineers fully recognizes that the term "engineer" should be limited and that surveyors, mechanics, etc., should not be included.

The writer's concept, which closely resembles the idea conveyed by the present paragraph governing admission to the society, may be expressed in the following words:

An Engineer.—One who through training and experience has acquired such full and accurate knowledge of the laws of matter and of natural forces, that he can design structures, machines, or processes, for the utilization of said natural forces or properties, with accurate foreknowledge that they will efficiently perform the desired function.

Engineering.—The art or profession of designing structures, machines or processes, for the utilization of natural forces or properties with accurate foreknowledge that they will efficiently perform the intended function.

"Art," as engineering knows neither age nor sex; "training" includes all knowledge derived from external sources—study, instruction, reading, observation of others' work, etc.; "experience" includes only one's own original research and proficiency due to practice; "full and accurate" are terms expressing quantity and quality and are kept sufficiently elastic by the word "such"; "knowledge of the laws" is the one thing above all others that differentiates the engineer from the experimenter and investigator; "of matter and of natural forces", as both are necessarily incident to any useful structure, machine or process (natural forces include those pertaining to molecules and atoms as well as those pertaining to masses); "can design," as he is no engineer unless he can apply his knowledge; "design," as that is really the function of the engineer—a mechanic of very ordinary attainments can build a thing for which he is given plans or designs; "utilization of natural forces or properties," as utility is the only raison' d'etre of an engineer; "with accurate foreknowledge of results," as that differentiates from lucky guessing and puts his work on a scientific basis; "efficiently perform," as it is not engineering to use ten pounds of material where one will suffice; "efficient" is, of course, a relative term and must be limited by the "state of the art."

Note that the fundamentals are design (based on knowledge) for utility; knowledge of laws involves foreknowledge of results and efficiency. One who builds is an engineer only in so far as he must design auxiliary machines, structures or processes. So far as he follows the design of others he is a mechanic only. Engineering necessarily involves *creation* of means to an end. Investigation and experiment while usually done by engineers are really no part of engineering; they determine the laws. Engineering begins with the known laws, and concerns itself solely with their application. Note that the definition covers all the recognized branches of the profession; the farmer becomes an agricultural engineer only when he has knowledge—creates a new design—not guessing or hoping for results, but knowing. So with the chemical engineer, if that branch can really be recognized.

The writer does not expect every one to agree that his definition is the only one, or even the best. He has discussed it rather fully to forestall as many objections as possible. The definition fits the writer's idea, and, he believes, the idea held by most actual engineers. It also agrees in all essential elements with the present constitution of the American Society. A given term of practice is not essential to the definition, but is properly a prerequisite of membership.

The prefix civil is not discussed, as it is a survival of an obsolete distinction. The writer would be glad to see it dropped. The writer does not consider the vague distinction of civil as opposed to mechanical—electrical—mining, etc., to be worthy of attempted definition. The work of recognized civil engineers includes so much of the others and vice versa, that a logical division does not seem possible. They are all really branches or specialties included within the term "Civil Engineer."

Herman K. Higgins,
Assoc. Member American Society of Civil Engineers;
Assistant Engineer, Isthmian Canal; formerly Assistant Engineer, N. Y., N. H. & H. R. R.
Cristobal, Canal Zone, Feb. 8, 1907.

Water Storage and Water Power Development in the State of New York.

Sir: It would be a fortunate thing for this state if every citizen could read the editorial which appeared in the last issue of Engineering News on the subject of water storage. You say that "sooner or later these (storage) reservoirs must be created as a means of scientific river regulation." Despite the undoubted truth of that fact, misleading propaganda, spreading the alarm that the Forest Preserve is on the verge of ruin, is being scattered throughout the state.

As an officer of the Forestry, Water Storage and Manufacturing Association, which is supporting the proposed constitutional amendment permitting the use of small areas of state land for water storage, I would like to call attention to one or two points made in your editorial. You say, with perfect truth, "that the necessity for placing such a system (of water storage) under state control is apparent." Do you think that the proposed constitutional amendment, if adopted, could have any tendency to endanger such control?

To the State Water Supply Commission is given entire supervision over all river improvements. It makes surveys, holds public hearings and makes recommendations to the Legislature. Not a pick or a shovel can be lifted on a work of river improvement until the Legislature has approved the Commission's recommendations, in every detail, and until the Governor has approved the action of the Legislature. It seems hardly possible to provide more safeguards against the state's losing control over its land and waters.

Under present conditions its ownership of one-tenth, or of one-twentieth, of the land needed for a river improvement might keep the state from undertaking the improvement! In other words, the state is put in the queer position of being able to condemn the land of private parties and to have the land flooded, but cannot use an acre of its own forest land. In many cases the proportion of state land needed is very small and engineers calculate that in the whole state only 17,000 acres of state land, or about 1% of the public holdings, will have to be flooded for all the reservoirs proposed.

Now, as to expense: None of the state's money is spent on river improvement. The cost of every improvement is apportioned among those who directly benefit from it. Not a foot of land does the state lose; on the other hand, it acquires new property rights which will become very valuable. Upon the completion of an improvement it is given over to the state to control absolutely and permanently.

The manufacturing interests which are supporting this amendment are not to get anything for which they will not pay well; the benefits they derive will be perfectly legitimate. With a complete water storage system the state will control the headwaters of its streams much more securely than it can possibly do under existing conditions. The benefit to the commonwealth as a whole will come about in the prevention of floods, the industrial growth due to the development of water resources which are now going to waste, the affording of a larger supply of water for navigation in the dry season, and the improvement of sanitary conditions in many cities and towns.

If the amendment is adopted the state will have what improvements it thinks are for its good and no more; if the amendment is not adopted the state cannot have an adequate scheme of river regulation under its own control or otherwise. Not to be willing to give the state power to put into effect improvements is to say that the whole machinery and system of government cannot be trusted. And if that is the case then what purpose do laws and constitution serve, anyway, since the constitution and the laws must depend upon executive officers and lawmakers for enforcement?

In this case there is no reason for manufacturing interests to seek benefits by illegitimate means, because there is so much water power going to waste that "there is plenty for everybody." And the manufacturers, under governmental control, will help create wealth which will be passed on to laborer and consumer and will, in that way, add to the prosperity of the state.

Yours very truly,

Chester W. Lyman,
Secy. Forestry, Water Storage and Manufacturing Assn.
30 Broad St., New York City, Feb. 9, 1907.

[Our correspondent says: "The manufacturing interests which are supporting this amendment are not to get anything for which they will not pay well; the benefits they derive will be perfectly legitimate."

Does he mean by this that the owners of water-power sites are willing to accept the principle that the additional power which will become available at these sites when the state builds reservoirs on the streams above will belong to the state and not to the private owners?

Apparently, from the rest of his letter, he does not mean this at all. He would have the reservoirs built by the state and the cost "apportioned among those who directly benefit from it." In other words, the profit from the water-power development, over and above its cost, is to go to the pockets of private owners and not to the state. If this is the position of our correspondent and those he represents, then his views and ours are diametrically opposed.

He speaks of "apportioning the cost of river regulation among those benefited." This principle is undoubtedly correct when applied to works of channel improvement and control, such as levees; but when the control of streams by building reservoirs on its headwaters is attempted, the system of assessment for benefits would break down of its own weight. Suppose, for the sake of argument, the work of building reservoirs on the upper Hudson and its tributaries were undertaken. Nobody in the world is wise enough to distribute the cost of such reservoirs equitably between all the different lands and properties whose danger of flood damage is reduced and all those which benefit by the creation of water power. No one can say what water powers may be worth ten or twenty or forty years hence. No one can say, even approximately, how far a reservoir system will reduce the high water mark of maximum floods.

Again, in any such water storage system it would be a mistake nothing short of a crime to let any private water-power owners acquire any vested rights. Much of this stored water may some day be in demand for city water supplies; and the state ought therefore only to lease and not to sell the new water powers which its reservoirs will create.—Ed. Eng. News.]

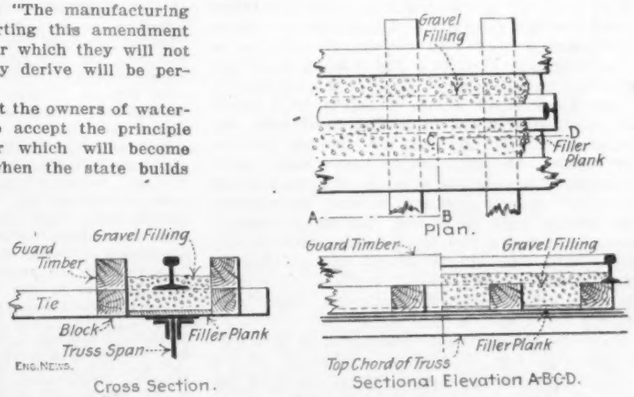
Notes and Queries.

An error in describing the Melan-arch design for the Grand Avenue Viaduct in Milwaukee, Wis., occurred in our last issue. The 100-ft. span crossing 38th St. has a rise of 15 ft., like the 60-ft. span, and not a rise of 28 ft. The design thus separates the central portion of the viaduct completely from the terminal portions, as the view Fig. 1 on p. 178 of our last issue (Feb 14) clearly shows.

A NOISE-DEADENING EXPERIMENT ON THE CHICAGO ELEVATED LOOP.

As a result of the agitation over the noise caused by traffic on the terminal loop line of the Chicago elevated railways, an experiment with a sound-deadening arrangement is being made on a short stretch of the line in Wabash Ave. The track of the loop consists of T-rails laid on ties resting upon the deck trusses of the structure. For the experiment in question, fillers were placed between the ties, upon the tops of the trusses, and blocks were fitted between the ties in the spaces under the guard timbers; thus forming a series of pockets. Gravel filling was placed in these, and carried up to about the middle of the rail. The construction is shown in the accompanying sketch.

This method does not appear to have much, if any effect in reducing the noise, either in the trains or in the street. It will be seen that it serves merely to deaden the noise due to vibrations in the rails, and as it does not insulate the rails from the ties or the ties from the steel structure, there is little reduction in the vibrations set up in the structure. It also, of course, has no effect upon the noise due to the cars, trucks and loose fittings (gates, guard chains and guard gates, couplers, etc.). The gravel causes dirty water to drip from the structure in wet weather, and the trusses are splashed and discolored with it. It appears evident that something more radical will be required to effectively reduce the noise that now makes the elevated loop such a nuisance. The subject as a whole was discussed two years ago in a report by Mr. B. J. Arnold, an abstract of which was published in our issue of March 23, 1905.



EXPERIMENTAL NOISE-DEADENING ARRANGEMENT ON THE CHICAGO ELEVATED LOOP.

A VERY LARGE DRY DOCK is to be built by the San Francisco Dry Dock Co. at Hunter's Point, South San Francisco, where the company already has two docks, 492 ft. and 750 ft. long. The new dock will be 1,050 ft. in length, 365 ft. deep over the sill nearly 200 ft. wide at the top. Plans for the dock are being made by Howard C. Holmes, M. Am. Soc. C. E., Ferry Building, San Francisco. The dock will be excavated mostly in solid rock. The estimated cost is $1,250,000.

A USEFUL TYPE OF TIDE-GAGE OR WATER-LEVEL INDICATOR.

A novel water-level indicator, applied to a continuously recording tide-gage, has been used in the hydrographic service on the Gironde River, in France. The apparatus bases on the principle of counterbalancing the head of water, whose height is to be measured, by compressed air which automatically assumes the equivalent pressure, and then measuring the pressure of this air by ordinary gages at the receiving end. Thus, the only connection required between the point of observation and the gage station on shore is a small tube carrying air.

The principle of this apparatus is more fully defined by the accompanying sketch Fig. 1, given in "Le Genie Civil" after the "Annales des Ponts et Chaussees." Here E represents a body of water whose variations of level are to be indicated or registered; $b\ t\ a$ represents an air-tube whose open outer end b extends into the water, well below the lowest ebb level; T is a reservoir of compressed air, whence a tube $r\ t$ fitted with a valve r leads into the main air-tube $b\ t\ a$; and a is a pressure-gage adapted to measure the pressure in the air-tube, and fitted either to indicate or, as suggested in the sketch, to record continuously on a moving chart. The compressed air stored in tank T must be at a higher pressure than the maximum head at point b. The valve r is nearly closed, so as to permit only slow leakage of the compressed air into the main air-tube; generally a reducing valve would be interposed between the tank and the feeding-valve r, permitting a very high storage pressure to be carried in tank T while giving a much lower but constant pressure above the feeding-valve.

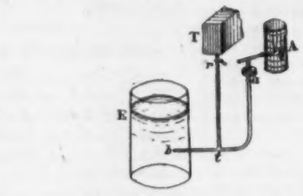


Fig. 1. Diagram Illustrating Principle of Tide Gage Indicating by Compressed Air.

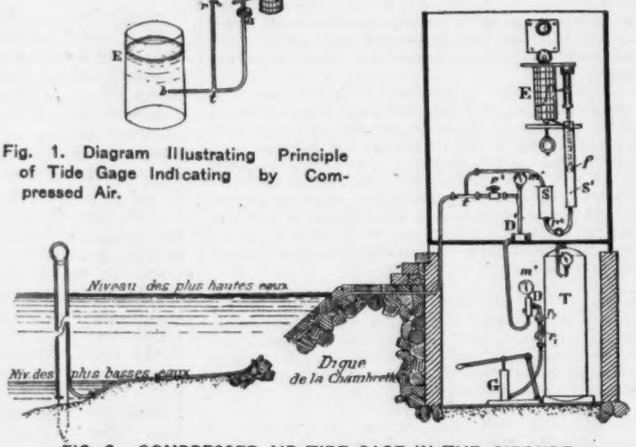


FIG. 2. COMPRESSED AIR TIDE GAGE IN THE GIRONDE.

The water above b will, of course, tend to fill the air-tube and rise in it to a level with the water surface E. But the air escaping through the feeding-valve r drives back the water, until a bubble of air escapes at b. In this process the air of necessity assumes a pressure corresponding to the head on b, and this same pressure exists at point a and is there measured by the gage. The flow of air is slow but continuous, forcing out a succession of bubbles at b and maintaining a pressure within the tubes constantly equal to the head on b.

An actual installation utilizing this principle is shown in Fig. 2. This is a tide-gage at the seawall at Pointe de Grave, at the mouth of the Gironde. The air-tube is here carried up well above high-tide level, and thence turns down, terminating below low water. A single pile supports the tube. From the water end, which is placed a convenient distance out from shore, the air-tube, a copper tube of ⅛-in. internal diameter, extends along the bottom and through the slope-wall to the recorder-house. In Fig. 2 T is the compressed air tank, of about 18 cu. ft. capacity; a hand-pump G is provided for charging it by way of the valved connection r_1. The pipe leading from the tank to the main air-tube contains a cut-off valve r_2, and two reducing valves in series, D and D', with gages m' and m'' as a control on their action. Beyond the second reducer is the feeding-valve r_3; the junction t, just beyond this latter, corresponds to junction t in Fig. 1. The recording gage SS' measures the air-pressure in the tube, and registers it on the clock-driven drum E. The gage is a mercury U-gage, with float f in the far branch; a valve r_4 in the bottom of the U gives a means for damping the oscillations of the mercury column in case of rapid fluctuation of water-level, as in a heavy sea.

In this installation, which is required to measure differences of water-level of about 20 ft. as a maximum, the second reducer D' is set to give a pressure of about 15 lbs. per sq. in. between D' and r_3. The mean daily discharge of air is about 16 cu. ft. free air. Experience in the waters of the Gironde has shown that this flow is sufficient to prevent any obstruction of the air-tube by deposits or by growths.

THE PANAMA CANAL ORGANIZATION has undergone several changes lately. As noted in our issue of last week, Principal Assistant Engineer Joseph Ripley, M. Am. Soc. C. E., has been made Assistant Chief Engineer in charge of the design and construction of locks and spillways, while Mr. F. B. Maltby, M. Am. Soc. C. E., takes the position vacated by Mr. Ripley. He will be in charge of all construction work on the Colon, Chagres and La Boca divisions. Mr. Wm. Gerrig, Division Engineer of the La Boca Division, has been transferred to be Division Engineer of the Colon and Chagres Divisions, and Mr. W. C. Comber, Resident Engineer, has been appointed Division Engineer of the La Boca Division.

On Feb. 14 President Roosevelt sent the following nominations of Isthmian Canal Commissioners to the Senate:

Chairman, Mr. Theodore P. Shonts; Chief Engineer, Mr. John F. Stevens; Civil Engineer, Brig. Gen. Peter C. Hains (retired); Messrs. Mordecai T. Endicott, Benjamin M. Herrod, Col. W. C. Gorgas, U. S. A., and Jackson Smith. Col. Gorgas is the head of the Department of Sanitation, and Mr. Smith the head of the Depart- Department of Labor, Quarters and Subsistence.

Referring to Mr. Shonts' nomination, although he intends to retire on Mar. 4, a statement has been given out at the War Department as follows:

> Mr. Shonts expects to retire March 4 next, but in view of the fact that the names have not been sent to the Senate before, and it was proper to secure confirmation, this list was sent in, although a vacancy will occur after the adjournment of Congress in the resignation of Mr. Shonts. It is expected to make Mr. Stevens Chairman of the Commission, and the other vacancy thus caused in the Commission has not been determined upon.

THE FOUNDATIONS FOR THE GATUN LOCKS have been the subject of some lurid statements in the daily newspapers lately. As an appropriate answer to these published statements, Chief Engineer Stevens has sent to the Senate Committee on Interoceanic Canals samples of the borings taken at the lock sites at Gatun and Pedro Miguel, with the following expressive comment:

> I have seen press statements lately that these drills have encountered mud and water, and material of similar nature. All of these statements are absolutely and unqualifiedly false. The drills have passed through nothing and encountered nothing excepting the material I have described and the samples of borings which I have sent you. Nothing in any investigation which has been made during the last year and a half has tended to show but that the foundations of the Gatun locks will be as solid as the eternal hills, and any statements to the contrary are either the products of diseased imaginations or wilful lies.

A LOCOMOTIVE BOILER EXPLOSION on the New York, Ontario & Western R. R., near the village of Luzon, N. Y., Feb. 13, killed two men, demolished the baggage car and ditched four passenger coaches. The train carried about 50 passengers, the majority of whom escaped serious injury.

A REAR COLLISION occurred between a accommodation train and an express on the Fitchburg Division of the Boston & Maine R. R. at Somerville, Mass., Feb. 14. The local train was held up by a block signal and was struck by the following express, which was proceeding under caution. The rear car of the local was badly damaged and nine passengers injured.

A REMARKABLE DERAILMENT occurred on the Harlem Division of the New York Central & Hudson River R. R. on the evening of Saturday, Feb. 8. A northbound suburban train, which left the New York terminal about 6.30 p. m., was derailed on a curve, a short distance north of Bronx Park, about 10 miles out. All but one of the coaches were thrown over and partly destroyed; 22 persons were killed and over a hundred injured. The derailment occurred on a four-track section of heavily-traveled and excellently-maintained track. The train consisted of two electric locomotives and five cars; it was filled with passengers. Electric operation of trains on this division had been inaugurated only a few days before, on a terminal section of some 12 miles. The suburban trains are intended to be multiple-unit motor-car trains, but as the furnishing of motor cars has been backward the initial service was arranged by hauling the ordinary trains with the 96-ton electric locomotives provided for hauling the heavy through trains in the Electric Zone. In the present case two such locomotives were used because on both locomotives some of the collector shoes were broken off, possibly because of bad ice troubles in the previous two weeks. One engine having still a full set of shoes on one side, while the other had a full set on the opposite side, by coupling the two together the possibility of being stalled at interruptions of the third-rail at crossings was avoided. The train was delayed some minutes at Mott Haven, 6 miles out, and then proceeded at its regular speed.

The testimony of the train-runner and a division superintendent who was on the engine agreed in estimating the speed of the train, at the time of derailment, as about 45 to 50 miles per hour. Various passengers, however, thought the speed was much greater, in fact greater than they had ever before experienced. The curve at which the train was derailed is a 3° curve (radius about 1710 ft.) and has a superelevation of 4½ ins. The track was laid with 100-lb. rail a year or two ago, and about a year ago was reballasted (broken stone) anad fitted with new ties. The train-runner was just about at the end of the curve when he "felt a tug at the engine" and saw blinding flashes of light; putting on the air-brakes he came to a stop about an eighth of a mile beyond. It appeared that he had with him the second engine and the first car; the other four cars were several hundred yards farther back, near the end of the curve, lying on their side on the outer (east) side of the track. They were off their trucks, which had not tipped. The first engine was entirely on the rails except its trailing axle; the second engine was entirely off the rails except its leading axle; and the forward truck of the smoker-baggage car (first car) was off the track. The tire retaining ring on one of the wheels of the front engine was broken. Several hundred yards back of the wreck of the cars, on the curve, a displaced rail was found in the outer (east) line of rail. This rail was shifted outward 5 ins. at its northern (forward) end; the spikes on the east edge were sheared off. The preceding facts are the total brought out so far, and they leave the actual cause of the derailment still a matter of doubt.

A SIDE COLLISION occurred in the yards at London, Ont., on Feb. 19. An eastbound freight train was pulling into a siding off the main line to get out of the way of a through express westbound. The express train came along at a speed reported at 30 miles an hour before the main track was clear and struck the rear cars of the freight train. The locomotive and baggage car were overturned and one man was killed.

A GAS EXPLOSION in the La Conquista Mine No. 3 of the Mexican Coal & Coke Co., at Las Esperanzas, Mexico, Feb. 18, killed some 60 or more miners and injured eleven others, two fatally. The accident is said to have been caused by a defective safety lamp, which ignited the gas. The mine is over 3,500 ft. deep and rescue work is slow.

THE EXPLOSION of a donkey engine boiler on the Hamburg-American steamship "Valdivia," Feb. 13, while the ship was about 100 miles south of Cape Hatteras, killed seven men, injured four others and badly damaged the steamship. The boiler was being used to raise ashes from the stoke hole when the accident occurred.

THE PENNSYLVANIA R. R. TUNNEL across Manhattan Island, New York City, has recently given rise to grave difficulties in the execution of the work. The contract for the section from the Terminal Station at Seventh Ave. east to the East River, about three-quarters of the width of the island, is let to the United Engineering & Contracting Co., which has completed over half the length of its work by continuous rock

tunnelling from four shafts. The contract calls for a double-track tunnel in 32d St. and a similar one in 33d St., from the East River to Fifth Ave., and a three-track tunnel in both streets thence west to the Terminal Station; the excavation of the double-track section is now practically done. The finished section has dividing walls (concrete) between tracks, but the rock was excavated in a single wide tunnel with flat arched roof. The depth of the floor below the street surface is in the neighborhood of 90 ft. Generally, there is a cover of 20 to 40 ft. of rock over the tunnel roof. At several points, however, there are dips in the rock surface which reduce the cover to 10 ft. or less. Several of these points in the two-track section required shoring of the roof, but gave no greater trouble. It happens that the lowest dip of the rock surface occurs just where the three-track section begins; the material overlying the rock at this point is sand, being in the valley of a former creek. It was known from the preliminary borings that the rock surface here came down to within a few feet of the tunnel roof, but it was thought that with care the tunnel could be pushed past this region without incident. The heavy structure of the Waldorf-Astoria Hotel on 33d St. and Fifth Ave., and other buildings, made the problem a delicate one. The tunnel reached the point of anticipated difficulty over two months ago. It appears now that the task has proved too dangerous, for a week or two ago the contractors made application to the Board of Rapid Transit Commissioners for permission to excavate the tunnel between Fifth and Seventh Aves. by excavation from the surface. They set forth, with the backing of several expert engineers' reports and the favorable opinion of the Board's chief engineer, that the continuance of tunneling in this section would endanger the buildings along 33d and 32d Sts., as well as the tunnel itself, and that it would be impossible to protect and underpin the foundations of the buildings properly. Strong opposition at once was heard from the property owners and lease-holders affected, but much of this has been overcome since the first application, and on Feb. 15 the Board of Rapid Transit Commissioners granted the desired permit for opencut excavation of 1,400 ft. total length.

THE EIGHT-HOUR DAY LAW on government work is once more to be tested. The grand jury of the United States district court, sitting at Cleveland, Ohio, last week brought in indictments against eight prominent contractors, principally working on harbor work on the Great Lakes, for violation of the federal law prohibiting a working day of more than eight hours on any government work. As this is by far the largest list of indictments brought in since the President ordered the enforcement of this law last summer, it is expected that the cases will be taken to the highest courts and the constitutionality of the law finally decided upon.

A CAUSEWAY FROM GALVESTON ISLAND to the mainland is to be constructed to replace the present timber trestle over which the railways enter the city. The Railroad Commission of the State of Texas, which is one of the most powerful of the State Railway Commissions, has ordered all the railways entering the city over this light and dangerous timber trestle to submit plans and specifications for the construction of a causeway not less than 140 ft. in width, with concrete side walls and constructed upon the most modern and substantial plans.

A POWER PLANT ON THE SOULANGES CANAL is to be constructed by the Montreal Light, Heat & Power Co. for supplying current over a high-tension transmission line to the company's distribution network in Montreal. Water will be taken from the Soulanges Canal by a new canal some 3,000 ft. long, 160 ft. wide at bottom and 27 ft. deep, which is now in course of construction. The power-house will be situated on the bank of the St. Lawrence River. The canal is to terminate above a reinforced-concrete dam 80 ft. in maximum height, just above the power-house. The wheels operating under an effective head of 50 ft., will generate an ultimate output of 20,000 HP., though only part of this capacity will be put in at the beginning. The power is to be transmitted to Montreal by a 50,000-volt line some 27 miles long crossing the rivers and canal by aerial spans. The cost of the whole enterprise is estimated at $1,500,000. Mr. R. S. Kelsch, of Montreal, made the designs for the works, in association with Mr. W. McLea Walbank, Vice-President and Chief Engineer of the company.

THE DRAINAGE INVESTIGATIONS OF THE U. S. Department of Agriculture are increasing in extent and importance. There have recently been taken up a preliminary survey of the Florida Everglades, a survey of the Black Bayou in the Yazoo District, Mississippi, and surveys along Little Forked Deer River. In the appropriating bill for the next fiscal year, already passed by the House of Representatives, $150,000 is included for these and similar investigations. The work now being done in the Everglades includes the running of a line of levels from the west to the east side of the glades—a task never before attempted. This survey was begun at Fort Myers in January, 1907, and is in charge of Mr. John G. Stewart, assisted by Mr. Lawrence Brett and others. The survey line will connect the surveys of Lake Okeechobee with tide-water on the east coast. Examinations will be made of the physical structure and depths of muck or other material overlying the substratum of rock which is said to extend beneath the whole area. The study of the Everglades will, it is hoped, determine the most feasible and practicable plan for draining the whole or part of the area, and an estimate of the agricultural value of the land when reclaimed. Mr. Elwood Mead, M. Am. Soc. C. E., is Chief of Irrigation and Drainage Investigations, and Mr. C. G. Elliott, M. Am. Soc. C. E., is Drainage Engineer, under the U. S. Department of Agriculture, Washington, D. C.

PRIZES AMOUNTING TO $1,200 for designs for suburban dwelling houses of concrete construction are offered by the Association of American Portland Cement Manufacturers. Six different classes of houses are scheduled and prizes of $100, $60 and $40 are offered for the first, second and third designs in each. All drawings entering the competition must be sent in by April 15 next. The designs will be judged by a committee consisting of two architects and one civil engineer. A full program of the competition will be mailed on request, addressed to the Secretary of the American Portland Cement Manufacturers' Association, 1232 Land Title Building, Philadelphia.

THE CAMDEN-ATLANTIC CITY ELECTRIC RAILway of the West Jersey & Seashore R. R. Co. (Pennsylvania R. R. System) has already called for additional equipment, though the line is in operation only six months. New motor cars, 21 in number, have been ordered, a fourth 2,000-KW. steam turbine generating set of Curtis type for the main power-house, together with additional boiler and auxiliary equipment, and six 1,000-KW. rotary converters for the sub-stations. The motor cars each have two 200-HP. motors with Sprague General Electric multiple-unit control, and are the same as those now in use. The additional generating and auxiliary apparatus also is substantial duplication of present apparatus. Like the original equipment the additional machinery is being built by the General Electric Co.

TRADE BETWEEN THE UNITED STATES and its possessions is assuming large proportions. In the calendar year 1906, the shipments to and from Alaska, Hawaii, Porto Rico and the Philippines were as follows:

	Value of shipments— From U. S.	To U. S.
Alaska	$17,378,000	$12,002,000
Hawaii	12,431,000	29,329,000
Porto Rico	22,000,000	20,710,000
Philippines	7,102,000	10,104,000

The above figures are for merchandise only, and do not include gold and silver, of which Alaska shipped $25,000,000 in 1906. It is surprising at first that the Philippines, with their enormous territory and population, should show so small a volume of trade with the United States; but it must be remembered that they are distant nearly half the circumference of the globe, while for the other possessions the United States is their nearest market for purchase and sale.

APPRENTICESHIP COURSES are to be established by the Bethlehem Steel Co. for the training of boys to become expert mechanics. A technical school will be established in connection with the plant at Bethlehem, Pa., and the apprentice will be given courses in both the school and the shop, in order to give him a thorough understanding of his work. Each apprentice will be paid small wages at the beginning, and as they advance their wages will be increased. In addition, money prizes and sets of tools will be given to those showing the greatest efficiency for given periods. Some of the trades to be taught are: brass molding, both bench and floor work; iron molding, bench and floor work; the laying of fire brick and the manipulation of fire clays in building up furnace linings; electric wiring, care of dynamos, batteries, and electric motors; steam fitting; tool making, including all kinds of tools and dies; armor plate and projectile making, including molding of ingots, heating, forging and annealing. The company offers to employ 3,000 youths under these conditions, the requirements for admission being simply to apply at the gates of the works.

FLEXIBLE CORD CONDUCTORS, both for pendant and portable use, as manufactured under the rules of the National Board of Fire Underwriters and recommended by the Underwriters' National Electrical Association, will after March 1, 1907, be made up under new specifications and be tested under the directions of the Wire Inspection Bureau. The test is to be as follows: Each coil of duplex cord must withstand a pressure of 1,500 volts alternating applied simultaneously to each of the two conductors contact being made on the bare copper wires at either end of the coil and care taken that the other ends of the conductors do not come together.

PERSONALS.

Mr. Edward H. Mason has been elected President and General Manager of the Colombian Pacific R. R.

Mr. Columbus Haile, Traffic Manager of the Missouri, Kansas & Texas Ry., has been appointed Vice-President.

Mr. Louis Titus has been elected President and General Manager of the Peoples' Water Co. of Berkeley, Cal.

Mr. William J. Boyhan has been appointed Superintendent of Sewers of New York City, at a salary of $5,000 per year.

Mr. W. W. Wheatley, General Manager of the tramway lines of the City of Mexico, has resigned to enter private business in that city.

Mr. H. R. Southworth, formerly of Binghamton, N. Y., has become Manager of the Publicity Department of the General Fireproofing Co., at Youngstown, Ohio.

Mr. L. S. Berg has resigned as President of the New Orleans Terminal Co. and will devote his time to developing the Baton Rouge, Hammond & Eastern Ry.

Mr. H. E. Culbertson, Engineer of Maintenance of Way of the Cleveland & Pittsburg Division of the Pennsylvania system, has resigned on account of failing eye sight.

Mr. E. L. Verveer, Assoc. M. Am. Soc. C. E., has been appointed Assistant Chief Engineer of the Southwestern Bridge Co., of Joplin, Mo. He will have charge of the Estimating and Designing Department.

Mr. S. W. Hayes, M. Am. Soc. C. E., President of the Hayes Track Appliance Co., Geneva, N. Y., was married to Miss Edna H. Burbank Feb. 3, at Santa Rosa, Cal.

Mr. D. W. Harvey, formerly Assistant to General Manager of the Mexican Ry., has been appointed Assistant General Manager of the National lines of Cuba, with headquarters at Havana.

Mr. Edwin S. Cramp has resigned as Vice-President of the William Cramp's Sons Ship & Engine Building Co. His withdrawal removes the last member of the family of that name from the company.

Mr. E. F. Peabody, Jr., has been appointed Contracting Manager at Minneapolis, Minn., of the American Bridge Co., to succeed Mr. Edward E. Green, transferred to the St. Louis (Mo.) office.

Mr. Wm. H. Cushman, M. Am. Soc. C. E., formerly Chief Engineer of the Juniata Hydro-Electric Co., of Huntingdon, Pa., has opened an office at 18 Exchange Pl., New York City, as a hydraulic engineer.

Mr. E. E. Johnson, Local Agent for the International & Great Northern R. R. at Mart, Tex., has been appointed Assistant Superintendent of the Fort Worth Division of that road, to succeed Mr. M. H. Trice, promoted.

Mr. Findlay S. Douglas has been appointed Manager of Motor and Generator Sales for the New York office of the Sprague Electric Co. He has been connected with the Sales Department of that company for several years.

Mr. D. H. Lewis, of Tribes Hill, N. Y., has been appointed by Superintendent of Public Works Stevens, Superintendent of the Eastern Division of the Erie Canal at a salary of $3,000 per annum. He succeeds Mr. John N. Parker, resigned.

Mr. W. L. Derr, Division Superintendent of the New York, New Haven & Hartford R. R., Hartford Division, has resigned to become Superintendent of the Eastern Division of the Chicago & Alton Ry., with headquarters in Bloomington, Ill.

Mr. J. C. Ralston, M. Am. Soc. C. E., who underwent a serious operation some six months ago at Rochester, Minn., is convalescing at his home in Spokane, Wash. He is as yet unable to personally attend to business, but retains his office at Oakland.

Mr. W. L. Mattoon, Assistant Engineer Chicago, Rock Island & Pacific Ry. at Des Moines, Iowa, has resigned to accept service with the Toledo & Ohio Central Ry., as Division Engineer of the Corning Division, with headquarters at Columbus, Ohio.

Mr. Samuel B. Rambo, Superintendent of George F. Payne & Co., Contractors, Philadelphia, Pa., has been appointed by Governor Stuart Superintendent of Public Grounds and Buildings of the Capital, Harrisburg, Pa. He succeeds Mr. James M. Shumaker.

Mr. Arthur H. Allen, formerly a member of the firm of H. B. Cummings & Co., Contractors, Boston, Mass., and recently in business for himself, has removed to San Francisco, where he will be connected with the Western office of Frank B. Gilbreth, General Contractor, New York City.

Mr. Clyde M. Graves, General Manager of the Spokane (Wash.) Traction Co., has been appointed General Manager of the Coeur d'Alene & Spokane Ry., to succeed Mr. R. F. Blackwell, whose resignation takes effect in March. Mr. Graves will continue as Manager of the traction company.

Mr. Henry Grinnell, late Forest Inspector of the U. S. Forest Service, has taken a position with the Carbolineum

Wood Preserving Co., of New York. His headquarters will be at Washington, D. C., and he will make a specialty of investigations relative to the preservation of mining timbers and telephone and telegraph poles.

Messrs. Herbert L. Sherman and Robert S. Edwards have formed a partnership under the firm name of Sherman & Edwards, Chemists and Chemical Engineers, 12 Pearl St., Boston, Mass. They will make a specialty of investigating cement and lime properties and designing and improving plants manufacturing these materials.

Obituary.

George Pearson, a retired contractor of Danville, Va., died in that city Feb. 12, aged 82 years.

Gerhardt Caesar, a mining engineer of Philadelphia, Pa., died at Detroit, Mich., Feb. 16, of pneumonia, aged 50 years.

Thomas A. Roberts, Division Superintendent of the Pennsylvania R. R., died at Philadelphia, Pa., Feb. 11, aged 66 years.

Schuyler Hamilton, a retired architect, formerly connected with the firm of Warren & Wetmore, New York City, died at his home in Norwalk, Conn., Feb. 13, of Bright's disease.

C. S. Ellsworth, Promoter and Builder of the Iowa Falls & Northern Shore Ry. and the Burlington, Cedar Rapids & Northern R. R., died at his home in Iowa Falls, Iowa, Feb. 15.

Thomas A. Scott, head of the T. A. Scott Wrecking Co., died at his home in New London, Conn., Feb. 17, of heart disease, aged 77 years. He built the Race Rock lighthouse, and superintended the work of laying the foundations of the piers for the Brooklyn Bridge.

Ashton Lemoine, a naval architect of New York City, dropped dead at the Bijou Theater Feb. 12. He was 52 years old and a member of the firm of Tams, Lemoine & Crane, Naval Architects and Marine Engineers, 52 Pine St. Mr. Lemoine was a graduate of Princeton University.

James Blake Cahoon, M. Am. Soc. M. E., Vice-President and Chief Engineer of the Eldenbel Construction Co., 42 Broadway, New York City, died at his home in New Rochelle, N. Y., Feb. 17. He was formerly an ensign in the U. S. Navy, but was retired seven years ago.

Willard Richards, at one time Superintendent of the New York & Greenwood Lake R. R., and Assistant Superintendent of the Morris Canal Co., died recently in Mexico, of fever, aged 57 years. He was a native of Newark, N. J., and for many years resided at Bloomfield, N. J.

Myron Edward Evans, Assoc. M. Am. Soc. C. E., President of the Cape Breton Ry. of Canada, was killed in the wreck on the New York Central & Hudson River R. R. at Bronx Park, New York City, Feb. 16. He was a graduate of Rensselaer Polytechnic Institute, class of 1895. His office was at 22 Pine St., New York City, and he was on his way to his home in White Plains when the accident occurred.

Major John A. Harman, Chief Engineer and General Manager of the Guayaquil & Quito Ry., died Feb. 9 at Quito, Ecuador, aged 42 years. He was born at Staunton, Va., and graduated from West Point in 1887. He was immediately assigned to the Seventh Cavalry as an additional lieutenant, and a month later became second lieutenant. In 1894 he was promoted to First Lieutenant of the Sixth Cavalry. From September, 1898, to May, 1899, he served as Chief Ordnance Officer of Volunteers in Cuba with rank of Major. He resigned in March, 1900, to become Chief Engineer and General Manager of the Guayaquil & Quito Ry. An article by Major Harman describing his road appeared in Vol. LII, No. 6, p. 115, of Engineering News.

George F. Wightman, Civil Engineer, of Lacon, Ill., who died Dec. 28, 1906, was one of the pioneers of Central Illinois, his parents settling in that part of the country in 1836. He was born in Ontario, Canada, Feb. 5, 1827. After serving in the army during the Civil War, he was engaged on various railway location surveys, and was at one time chief engineer on location of what is now a part of the Iowa Central Ry. He was City Engineer of Peoria, Ill., from 1881 to 1893; in the latter year he was elected County Surveyor of Marshall County, Ill., and held this position up to the time of his death. The pile and pontoon bridge over the Illinois River at Lacon was built to the designs and under the direction of Mr. Wightman in 1888.

Capt. George H. Kearney, U. S. N., head of the Steam Engineering Department of the Brooklyn Navy Yard, died at his home at Fishkill-on-the-Hudson Feb. 17, aged 59 years. He was appointed as a third assistant engineer of the navy on Oct. 10, 1866, and became an assistant engineer in January, 1876. On June 27, 1893, he was made a chief engineer, and was commissioned commander in 1899. He was detailed to the Boston Navy Yard in 1900, later being sent to the Brooklyn Navy Yard as head of the Steam Engineering Department. He had been home on sick leave since last November. He had served at the Pacific Station, the Asiatic Station, the Naval Academy and the Brooklyn Navy Yard before going to the Boston yard.

Thomas F. Griffin, a pioneer car wheel manufacturer and founder of the Griffin Car Wheel Co., died at Chicago, Ill., Feb. 11, of pneumonia. He was born at Limerick, Ireland, Dec. 18, 1826. Eight years later the family came to the United States and settled at Rochester, N. Y. Here he served an apprenticeship as a molder in the foundry of Traver & Benedict. In 1848 Mr. William Kid, a pioneer in the car wheel business, was admitted to the firm and the company then began the manufacture of car wheels under the Washburn patents. Mr. Griffin remained with this company, later known as the Kid Foundry, until 1873, when he removed to Detroit, Mich., to take charge of the Michigan Car Co.'s foundry, now a part of the American Car & Foundry Co. A short time later he left the employ of the Michigan Car Co. and engaged for himself. In 1875 he incorporated the Griffin Car Wheel Co., which now has plants at Boston, Mass., Detroit, Mich., St. Paul, Minn., Kansas City, Mo., Denver, Colo., Tacoma, Wash., and Chicago, Ill.

ENGINEERING SOCIETIES.

COMING MEETINGS.

ASSOCIATION OF ONTARIO LAND SURVEYORS.
Feb. 26. Annual Meeting at Toronto. Secy., Killaly Gamble, 405 Temple Bldg., Toronto, Ont.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 19-21. Annual Meeting at Chicago, Ill. Secy., L. C. Fritch, 1562 Monadnock Block, Chicago, Ill.

IOWA ELECTRICAL ASSOCIATION.
April 18-19. Annual Meeting at Clinton, Iowa. Secy., L. B. Spinney, Iowa State College, Ames, Iowa.

THE AMERICAN RAILWAY ASSOCIATION.
April 24. Annual Meeting at Chicago. Secy., W. F. Allen, 24 Park Pl., New York City.

APPALACHIAN ENGINEERING ASSOCIATION.—The annual meeting was held in the Chamber of Commerce Rooms, Charleston, West Va., Feb. 2, when the following officers were elected: President, Mr. Howard N. Eavenson; Vice-President, Mr. B. Burleson; Secretary, Mr. W. N. Mannakee; Treasurer, Mr. R. H. Buchanon.

ILLUMINATING ENGINEERING SOCIETY.—The regular meeting of the New York section was held Feb. 8 in the Edison Auditorium, 44 West 27th St., New York City. Officers for the ensuing year were elected as follows: Chairman, Mr. A. E. Forstall; Managers, Messrs. M. K. Ayer and T. R. Beale; Secretary, Mr. Preston S. Millar.

NOVA SCOTIA SOCIETY OF ENGINEERS.—At a meeting held Feb. 5 officers were elected as follows: President, Mr. R. McColl; First Vice-President, Mr. J. H. Winfield; Second Vice-President, Mr. P. A. Freeman; Secretary, Mr. E. Brydone-Jack; Treasurer, Mr. S. Fenn; Councillors, Messrs. Bogart, W. G. Yorston, J. J. Taylor and L. H. Wheaton; Auditors, Messrs. H. W. Johnstone and J. L. Allen. It was decided to hold the first annual meeting at Halifax, N. S., at a date to be determined by the council. Also that the society apply for a charter at the next meeting of the Legislature.

WESTERN SOCIETY OF ENGINEERS.—The program for the remainder of the meetings of the present season is as follows: Feb. 20—"Fire Protection of Fireproof Buildings," W. C. Robinson. March 20—"The Fuel Tests of the U. S. Geological Survey," L. P. Breckenridge. April 3—"Electric Lighting for Railway Trains," D. C. Jackson. April 17—"A Colorado Mountain Reservoir," R. M. Hosea. May 1—"Gas Producers and Producer Gas," R. H. Fernald. May 15—"Experimental Determination of Web Stresses in Plate Girders," F. E. Turneaure. June 5—"Methods of Pumping Deep Ground Water," C. B. Burdick.

INTERNATIONAL NAVIGATION CONGRESS.—The eleventh international congress will be held at St. Petersburg in May, 1908. The purpose of these congresses, which are held every three years, is, first, to create general interest in matters of navigation, naval construction and importance of waterways; second, the study of theoretic and practical questions relating to hydrotechnical construction (sea and river); third, the industrial, commercial and technical exploitation of rivers and seaports. Reports on these subjects will be publicly discussed and excursions made in order to study the hydrotechnical works, seaports and waterways of Russia.

NEW YORK RAILROAD CLUB.—The February meeting was held Feb. 15 in the club's new quarters in the Engineering Societies' Building, West 39th St., New York City. This was the first meeting of the club in this building, and the occasion called forth a large audience, some 350 persons being present. President Vreeland in opening the meeting gave a short resume of the history of the club. This is the oldest railroad club in the United States, and dates back to 1872. In that year several master car builders organized a society which they called the Master Car Builders Club, with [illegible] on Liberty Street. This society continued in [illegible] until 1889, when its name was changed to [illegible] New York Railroad Club and a broader policy adopted; since then the club has grown rapidly, and now has a membership of about 1,400 and is in a prosperous condition. The club has had three different homes since its organization, first rooms on Liberty Street, then [illegible] in the Mechanical Engineers' old building, West 31st Street, then rooms in Carnegie Hall, West 57th Street, and now they are permanently located in Engineering Societies' Building.

Mr. Forney, one of the oldest members of the organization, followed Mr. Vreeland, and recounted experiences of old days, when the society was struggling for existence. The technical paper of the evening was on "Varnish; the Last Thing Applied, but not the Least Important." The principal point brought out by the paper and the discussion that followed its reading was that it was practically impossible to determine whether varnish was good or bad until it had been properly applied and subjected to actual atmospheric and working conditions.

President Vreeland announced that the March meeting of the club would be the annual electrical meeting. Arrangments are being completed to have some of the leading engineers of the country give short talks on the special branch of electricity in which they are specialists.

NEW ENGLAND WATER-WORKS ASSOCIATION.—At the February meeting, held at Boston, President John C. Whitney presented a communication from an absent member, who asked for experience with universal joint cast-iron pipe. Mr. John H. Cook, of Paterson, N. J., described a double line of 12-in. pipe laid across the Passaic River, because it was convenient to make the bolted joints under water, with the aid of a diver. He also spoke of two or three miles of this kind of pipe which had been laid at Little Falls, N. J., some of it being under high pressure. None of this pipe has yet been laid very long. Mr. Charles W. Sherman, of Boston, raised the question of what would become of such pipe when the bolts rusted out, but no one seemed to have had experience in this direction. Mr. Wm. R. Conard, of Burlington, N. J., described some of the details of this pipe, and called attention to the fact that the 6-ft. lengths are cast horizontally, instead of vertically. Mr. Conard mentioned a line of this pipe laid some time ago in Atlantic City.

Mr. Wm. R. Conard then presented a brief paper entitled "Some Observations on Cast-Iron Pipe Specifications," suggested by his experience in testing pipes at the foundries, under the New England and other specifications. He showed first that since the adoption of the standard specifications of the New England Water Works Association, a gratifyingly large proportion of the pipe bought for the New England and Middle States had been purchased under these specifications, but that in other parts of the country the use of these specifications, or indeed of any specifications, was much less common. He showed that the number of classes or weights of pipes of the several sizes actually used were few, and questioned whether the number of classes in the standard specifications might not be reduced with profit. And he suggested that a minimum time for maintaining the hydraulic test should be stipulated, since, with the larger sizes, especially, it takes an appreciable time for water to penetrate the sinuous passages of pipe which is porous, especially since they are more or less obstructed by the pipe coating, and the water will rarely show on the surface in a short-time test. He also suggested the desirability of prescribing a test for special castings, which are now not tested, except by the hammer. As might be expected, this paper provoked considerable discussion. Mr. Frank A. McInnes, of Boston, questioned the sufficiency of the transverse test of strength as a test of the quality of the iron. Mr. Wm. E. Foss, of the Metropolitan Water-Works, Boston, called attention to the fact that large special castings of bends are always of less curvature than the nominal, for instance, a ⅛-bend would throw but 44° or 44½° instead of 45°. In very large pipes, where the deflection possible in the joints is small, this is a matter of considerable importance. Mr. Foss also called attention to the weakness of the casting on the outside of the pipe, in rings about 2½ ft. from each end, where the pipe is rolled on skids while the casting is hardening. These points are the ones where electrolytic injury generally develops. It would be very desirable to avoid this injury to the casting.

Mr. Walter Wood, of R. D. Wood & Co., spoke at some length on the points already raised, from the manufacturers' point of view. He advocated casting pipes with 6 or 8 ins. excess length on the spigot end, to be afterwards cut off, so as to avoid porous ends. He thought the bead on the spigot end unnecessary. Referring to the suggested testing of specials, he said that if this were to be done, in many cases it would be necessary to make the castings heavier in order to withstand the strains to which they would be subjected in stopping the openings during the test.

Mr. Wm. Lyman Underwood, of Belmont, Mass., gave an illustrated lecture on "The Work of the Maine River-Drivers."